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The Upper San Pedro River Basin of the United States and Mexico

A Resource Directory and an Overview of Natural Resource Issues Confronting Decision-makers and Natural Resource Managers

Contributors
Bureau of Land Management • Bureau of Land Management National Applied Resource Sciences Center • U.S. Fish and Wildlife Service • U.S. Geological Survey • National Park Service • USDA Agricultural Research Service

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PREFACE

The Upper San Pedro River Basin, which is shared by the United States and Mexico, is of local, national and international importance because of its natural and cultural resources. There is physical evidence that the Basin has been inhabited by humans for more than 12,000 years. Over the last five decades, numerous research projects and studies have been completed and many more continue.

Recognizing that it would be very difficult, if not impossible, to provide a comprehensive listing of all previous and ongoing research and studies within the Basin, this document is an initial attempt to provide the reader with a brief description, a consolidation of some of the existing data and information that is available, current issues from the Department of the Interior management perspective, and other ongoing efforts within the Basin.

One of the objectives for developing this report was to identify data gaps so that, in the future, attention could be given to filling some or all of them. The description of the fauna within the Basin has not been developed to the extent it could and should be. Details on the socioeconomic aspects of the area also are lacking. More information on cultural aspects, demographics, levels of employment, housing and basic services, education, health and land holdings would be of value. Additionally, current information on economic activities, such as livestock grazing, agriculture, mining, tourism and recreation, would be useful.

Thus, we welcome information regarding studies and research that addresses these issues and receipt of other contributions to this document that you believe would be of value to natural resource managers and decision-makers in the Upper San Pedro River Basin. Contributions should be sent to Mr. Beaumont C. McClure, Special Assistant for International Programs, Bureau of Land Management, Arizona State Office, 222 N. Central Avenue, Phoenix, Arizona 85004.

I. INTRODUCTION

A. THE UNITED STATES-MEXICO BORDER FIELD COORDINATING COMMITTEE

Seven bureaus within the Department of the Interior (DOI) have a role in the administration of programs or management of natural resources along portions of the international border with Mexico. These bureaus are the Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), Bureau of Reclamation (BOR), Minerals Management Service (MMS), National Park Service (NPS), US Fish and Wildlife Service (FWS) and US Geological Survey (USGS). Since these programs and resources are often interrelated or interdependent on one another, decisions by any single bureau can impact on one or more of the others. With this in mind, in August 1994, the directors of the above-mentioned bureaus chartered a United States-Mexico Border Field Coordinating Committee (FCC).

The FCC was established to help the various DOI bureaus make more informed decisions when addressing border issues, by encouraging greater coordination, enhancing communication between the field and headquarters offices on border issues, and by providing a focal point within DOI for those outside of the department that also are involved in border issues. The BLM, NPS and FWS co-chair the FCC.

The FCC has identified several priority issues on which to focus their efforts. One of those is the Upper San Pedro River Basin. This area was selected, in large part, because of the significant amount of work that is being done in the Basin by bureaus within DOI and by other agencies and organizations. Due to its unique character, the Basin also has gained national and international attention, contributing further to a significant level of interest in the management of its natural and cultural resources. An Upper San Pedro River Basin Issue Team has been established to assess and address the management issues affecting the Basin.

B. THE UPPER SAN PEDRO RIVER BASIN ISSUE TEAM

1. MISSION STATEMENT AND GOAL. The Mission Statement of the Upper San Pedro River Basin Issue Team is to "improve the quality of life in the Upper San Pedro River Basin through coordinated and informed decision-making affecting United States' and Mexico's resources." The Issue Team's goal is to "establish mechanisms to locate, acquire, and share natural resource data and information for decision-making in the Upper San Pedro River Basin." To do this, the Issue Team intends to document and characterize potential resource concerns and conflicts that will confront managers in the Basin and establish appropriate mechanisms to locate, acquire, and share natural resource data and information for decision-making. This report reflects the initial efforts of the Team to compile essential data and information.

2. DEPARTMENT OF THE INTERIOR ISSUES. The DOI is involved in a number of issues in the Basin. Many of these are associated with the San Pedro Riparian National Conservation Area (NCA) -- a riparian area and adjacent habitat set aside by Congress in 1988 for special management, in recognition of the unique riparian flora and fauna that exist in the area.

These biological resources are, in turn, dependent on the San Pedro river for their continued existence. Congress placed the responsibility for protecting these unique values with DOI, which administers the NCA through the BLM. Successful administration of this complex NCA requires widespread cooperation and resolution of the growing number of conflicts that exist on both sides of the international border.

Resource issues associated with the Basin are discussed in Chapter IV.D., Issues from the DOI Management Perspective. However, in brief, they tend to group themselves under the generic categories of Water Issues, Resource Protection, and Education Needs, as follows:

- ***Water Issues:*** These cover the spectrum and include water quality, continued availability of adequate supplies of both surface and groundwater, equitable distribution in the face of increasing demand, and insufficient knowledge of the hydrodynamics at work in the Basin.

  Competing demands, growth within the Fort Huachuca/Sierra Vista area, and over-pumping have reduced the amount of surface water available to meet current and increasing future user needs. Surface water that is available is being seriously stressed by the heavy user demands. Under-treated sewage and acid mine drainage are two factors contributing to lowered water quality in the Basin.

  The hydrologic relationship between groundwater and surface water in the Basin is not well understood, which hampers effective management and decision-making. There is a need to know more about how the pressures exerted on each system alone affect the other.

- ***Resource Protection:*** The resources in the Basin are interdependent on one another to a large degree. The riparian areas are dependent on the floral and faunal associations found within them, which, in turn, are dependent on a healthy watershed and adequate supplies of water. These limiting factors are affected by a variety of human activities, both directly and indirectly. Groundwater pumping alters the water balance, agricultural and extractive industries can effect water quality, and the growing popularity of the region brings increased visitation and increased human pressures on the natural resources of the Basin. All of these uses must be carefully managed to ensure the long-term health of Basin ecosystems.

- ***Education Needs*** - It is likely that the natural resource values and growing public demand for access to and use of the resources can both be accommodated through careful management built on sound scientific information. Managers, resource specialists and users need to develop a better awareness of how riparian systems function and how ecosystem components interact, particularly the relationship between ground water and surface water systems. Currently, our knowledge of these resource relationships is inadequate, and the information we have may not be effectively conveyed to others having a need for the information.

There are other important resource management issues of concern to DOI and to others residing in and near the Basin. DOI's interest in the flora and fauna of the Basin extends beyond the boundaries of the NCA. The water issues within the NCA are also concerns for the Coronado National Memorial and the Gila Indian Reservation, which are dependent on a healthy Upper San Pedro River Basin. As resource management agencies learn more about the unique character of the Basin and its significant values, they will need to consider the implications of their management decisions not only in a local and regional context, but in a national and international context as well.

The Upper San Pedro River Basin has received worldwide recognition for its wide variety of mammalian species, bats, and neo-tropical birds, as well as for its unique physical features, archaeologic sites and historical attractions. This international interest has led to an increase in tourism, scientific research and other uses that have added to the environmental stresses impacting the Basin and its resources.

DOI has a significant administrative presence in the region and employs within its scientific and resource management agencies some of the very best scientific expertise available. DOI, working in cooperation with Mexico, and other federal, state, local and private entities, is committed to being a responsible neighbor and applying that scientific expertise to solve the resource management problems in the Basin.

To effectively meet its responsibilities within the Basin, DOI must fully utilize its existing resources and expertise to improve understanding of the complex interrelationships that are at work, and to build an environmental model of the Basin for use by all managers.

C. PURPOSE OF THE REPORT

This report is written as a reference for resource managers and decision-makers whose administrative responsibilities fall within the Upper San Pedro River Basin. It is designed to help them better understand the spectrum of issues impacting the Basin and to provide them with some of the essential information needed to find solutions and help with future decision-making. Specifically, the report is intended to create a greater awareness of the problems and identify some of the tools available to address the problems. It is designed to provide a better understanding of the opportunities, responsibilities, and limitations of DOI and its resource management bureaus. The report is not intended to serve as a detailed manual; however, it hopefully, contains enough relevant information to enable managers to conceptualize how their bureaus can contribute to solutions, determine what additional expertise should be obtained, identify potential impacts their decisions might have, and recognize the potential benefits they might realize through cooperation with others.

II. BACKGROUND

A. INTERNATIONAL CONTEXT *(Much of this Section A. was developed from Secretario de Infraestructura Urbana y Ecologica, 1994)*

The Mexican Republic is a biologically rich area. It contains much greater biodiversity than would normally be expected for a country of its size. This derives from the position Mexico occupies between the two largest biogeographic regions of North America, which are known in geographic terms as the Neotropical and Nearctic realms. The wealth of species in Mexico has long been recognized by naturalists and scientists throughout the world.

With respect to plants alone, almost all the known vegetative types are found in Mexico. Only India and Peru have a comparable diversity in vegetation. The number of vegetative species classified to date in Mexico has been estimated at between 22,000 and 30,000, representing 220 families and 2410 genera. Ten percent of these genera and 52% of the species are indigenous to Mexico. These numbers underscore the importance of Mexico in the global context.

Mexico possesses similar global status with regard to fauna. The most studied faunal group is the vertebrates, of which the herpetofauna are particularly noteworthy. There are nearly 950 species of reptiles and amphibians in the country, representing 9.8% of the world's total. Of the known families of amphibians, over 35% occur in Mexico, including nearly 25% of the world's salamanders. With respect to reptiles, 58% of the recognized reptilian families have been recorded in the Republic of Mexico.

Among other vertebrates, 1,026 species of migratory and non-migratory birds are found in Mexico. In comparison, the United States and Canada combined have approximately 800 bird species, yet Mexico covers only 11% of their surface area. Of the non-migratory birds only 16.3% are indigenous or quasi-indigenous to Mexico (Escalante-Pliego, et al, 1993). There are 449 species of mammals known to occur in Mexico. Of this number, approximately 32% of the mammal species are indigenous. This tremendous biodiversity places Mexico among the few countries of the world classified as biologically "megadiverse."

This rich biological diversity is not confined to Mexico. The unique landscapes and geographic conditions which give rise to the "megadiversity" of Mexico also extend into the United States portion of the Upper San Pedro River Basin. They are observed in the form of the unique biological, riparian and scenic values preserved in the San Pedro Riparian NCA and in what one journalist with the New York Times described as "...an archipelago of magnificent mountain forests and grasslands rising from the desert like islands from the sea. They are called sky islands, and they are home to one of the richest panoplies of living creatures on the continent."

In May 1991, The Nature Conservancy, in conjunction with more than 100 public and private sector partners, focused international attention on the ecosystems of southeast Arizona and southwest New Mexico by declaring the region as one of 12 "Last Great Places" in the Western Hemisphere. The Upper San Pedro River Basin is included as an integral part of this effort to recognize conservation initiatives and protect functioning ecosystems that are at risk.

B. NATIONAL CONTEXT: MEXICO *(This Section B. was developed from Secretario de Infraestructura Urbana y Ecologica, 1994, except where otherwise indicated)*

The tremendous biological diversity and abundance of species is distributed throughout many comparably diverse ecosystems located in Mexico. Many of these biological resources are experiencing increasing environmental stress. Some are now threatened or endangered. Much of this stress is either directly or indirectly the result of industrial activities, primarily those exploiting Mexico's abundant renewable and non-renewable resources, or as a consequence of the secondary impacts of pollution and waste produced by production and processing activities. In addition, the growth and expansion associated with population centers further increases the demand for the natural resources that are often associated with the existence and continued survival of these endangered and threatened flora and fauna.

Fortunately, Mexico has recognized the problem and has responded over the past decade with new environmental policies aimed at reducing the environmental impacts associated with their tremendous growth. These policies have begun to show positive results, by slowing the trend and moving Mexico in the direction of better environmental protection and improved conservation of its natural resources.

1. SEDESOL/SEMARNAP. To support these new environmental objectives, the Mexican government has developed policies and strategies to achieve sustainable use and promote conservation of its natural resources. In May 1992, the Mexican government restructured the Secretariat of Urban Development and Social Development (SEDUE) to form the Secretariat of Social Development (SEDESOL) and its agencies, the National Institute of Ecology and the Federal Attorney's Office for the Defense of the Environment. It was given responsibility for the development and administration of the new policies. One SEDESOL initiative has been Mexico's National Development Plan (1989-94). Within the framework of this national strategy, Mexico has implemented the National Program for Environmental Protection (1990-94), and the General Law of Ecological Equilibrium and Environmental Protection (LGEEyPA), which regulates use, exploitation, and protection of natural resources. Mexico also has revised or updated much of its statutory and regulatory framework to complement and support the policy changes. Among the regulatory laws that have been revised are the National Water Law, Forest Law, Hunting Law, Agrarian Law, and Mining Law. These and other laws have been modified to incorporate the concept of preservation, conservation, and protection of natural resources that belong to the nation and are administered in the public interest.

In December 1994, responsibilities of SEDESOL, the Secretariat for Fishery Resources (SEPESCA), and some belonging to the Secretariat for Agriculture and Water Resources (SARH) were consolidated by presidential order to form the Secretary for the Environment, Natural Resources, and Fisheries (SEMARNAP). This presidential order combined responsibilities for natural resource management under one secretariat. SEMARNAP is responsible for promoting a transition toward sustainable development, reducing environmental degradation, and encouraging the proper use of natural resources (USEPA, 1996).

SEMARNAP consists of the Undersecretariat for Planning, Undersecretariat for Natural Resources, and Undersecretariat for Fisheries, and five decentralized management agencies: the National Water Commission (CNA), the National Institute of Ecology (INE), Federal Attorney General's Office of Environmental Protection (PROFEPA), National Fisheries Institute (INP), and Mexican Institute of Water Technology (IMTA). SEMARNAP also includes the National Commission for the Understanding and Use of Biodiversity (CONABIO) (USEPA, 1996).

2. STATE OF SONORA. The Mexican portion of the Rio San Pedro Basin is located within the State of Sonora. This Mexican state contains most of the unique geographical characteristics and much of the biological diversity that gives Mexico its status as "megadiverse." In the northern region, along the border with the state of Arizona, four relatively isolated "island" structures occur that are topographically elevated, but are separated by rugged ravines. Though the structures are part of the massive Sierra Madre Occidental mountain system, they are physically distinct and separate from the sierra range and have given rise to four distinct communities.

In recognition of the unique physical characteristics and biological associations found in this area, and in the great scientific value they represent, several Mexican Reserves have been established to conserve wild flora and fauna in the sierras La Mariquita and La Elenita, and along the Rio San Pedro.

The State of Sonora realizes the value of its natural assets. With the new umbrella conservation policies in place and a new national direction clearly established, Sonora has followed the national lead with a series of actions to help them deal with environmental problems they are experiencing at the state level, which include air pollution, water pollution, depletion of groundwater aquifers, deforestation, and soil erosion. Among the biological concerns they plan to address are the loss of plant life and habitat, the presence of exotic species (both flora and fauna), and the decline of native faunal species.

The Mexican government attributes a large part of the problem to two important industries: agriculture (primarily livestock grazing) and mining. Mexicana de Cananea Company operates one of the 10 largest open pit copper mines in the world. It is located in the headwaters of the Basin at Cananea, Sonora, Mexico. The mine is the principal generator of jobs and revenue in the Cananea area. This historic mining operation, which began in the late 1800's, employs many people in the Cananea area and continues to provide copper to an international market. However, potential impacts from the mining operation are of concern to land managers, administrators and others concerned with the health of the Basin, both in Mexico and the United States.

To help them deal with these environmental concerns, in 1980 the state government, working with SEDESOL and other entities, created Ecoplan, a state regionalization plan designed to guide the use and conservation of natural resources of the state of Sonora. Ecoplan, in turn, has provided the foundation for other state environmental initiatives which incorporate and help implement the national objectives. For example, the state government developed the State Development Plan 1992-1997, from which the State Environmental Program 1992-1997 is derived. The latter has as one of its main objectives the rational use of resources, ecological conservation, and environmental protection.

As one of the pro-environment actions, the program "System of Protected Natural Areas in the State of Sonora" (SANPES) was created. The Center for Ecology in Sonora studied those areas that, because of their natural characteristics, can be incorporated under a coordinated system of management. Sixteen areas have been considered by SANPES for classification as Protected Areas of Natural Resources. Among the areas recognized are Sierra La Mariquita, Sierra La Elenita, and Río San Pedro, in the Sonoran municipalities of Cananea, Naco, and Santa Cruz.

C. NATIONAL CONTEXT: THE UNITED STATES

Scientists, resource managers, and special interest groups have long recognized the significance of the Upper San Pedro River Basin. However, it wasn't until 1988 that a portion of the river received official recognition and limited protected status. In 1988, the United States Congress created the San Pedro Riparian National Conservation Area (NCA). This 56,000-acre (23,000-hectare) strip of land lies entirely within the United States. It begins at the United States-Mexico border and extends north about 36 miles (58 kilometers) to Saint David, Arizona, encompassing both sides of the San Pedro River. BLM manages the area for its riparian, wildlife, cultural, recreational and other natural resource values. The NCA supports significant biological diversity, with more than 400 bird, 84 mammal, 47 reptilian and amphibian species and habitat for 14 fish species. The area also contains vital habitat for several threatened and endangered species.

Another significant site within the Basin, the Ramsey Canyon Preserve, has been owned and operated by The Nature Conservancy since 1974. It is located ten miles from Sierra Vista and is probably the most well-known area within the Basin, primarily because of the wide variety of hummingbirds that return to the area year after year. Hummingbird species include the Magnificent, Blue-throated, and White-eared hummingbirds. Some bird species, like the Eared and Elegant Trogon, have been sighted at Ramsey Canyon during the nesting season, but are rarely found elsewhere in the United States.

Among the unique geological features that are found in the United States portion of the Basin, is Karschner Caverns, located near Benson, Arizona. The caverns were acquired by Arizona State Parks and will be opened to the public in the near future. This underground "living" limestone formation will attract additional international interest and visitation to the area.

These are some of the values and characteristics which led The Nature Conservancy to declare this region of southeast Arizona and southwest New Mexico one of 12 "Last Great Places" in the Western Hemisphere. In a survey by the *Wild Bird Digest*, southeastern Arizona was identified as the number one birding site in the United States in 1991, due, in part, to the birding values in the Basin. In 1996, the American Bird Conservancy designated the NCA as a Globally Important Bird Area. Because of the growing awareness of these natural resource values, the Basin is receiving greater recognition, more focused attention and increased visitation from throughout the world.

III. DESCRIPTION OF THE UPPER SAN PEDRO RIVER BASIN

For anyone who enjoys the bountiful resources of the Upper San Pedro River Basin, or is in the position of making decisions concerning their use, it is important to understand the entire context in which those values were created and continue to exist. Such context requires knowledge of the physical and biological conditions that currently sustain those resource values, and knowledge of how current trends may be changing those environments.

A. PHYSICAL ASPECTS

1. POLITICAL BOUNDARIES AND INFLUENCES. The San Pedro River actually extends far into Arizona, where it drains into the Gila River System and then into the Colorado River. The upper section covered by this report, the Basin, extends from the headwaters in Mexico, to the "Narrows" (a geologic formation) north of Benson, Arizona, about 55 miles (89 km) north of the international border. Roughly 72% of the area covered in this report is located in the United States. The San Pedro River is one of only a few rivers that flow from south to north in the North American continent. This creates the unusual condition in which the headwaters of the San Pedro River originate in Mexico, on the 28% of the Basin that is under Mexican jurisdiction, and drains northward into the United States. As a result, many of the issues associated with the surface and subsurface waters within the United States also have a strong tie to the policies and activities that take place in Mexico.

Most of the land embraced by this report was ceded to the United States after the Mexican War in 1848. However, the boundary eventually came under dispute. In 1853, a treaty was negotiated with Mexico to purchase the land. Following a bitter debate in Congress, the treaty was ratified in 1854, but only after the size and cost of the acquired territory was reduced considerably. As a consequence of these changes, the ratified treaty divided the Basin, placing the headwaters within Mexico. The Arizona Territory was established in 1863, and in 1912 Arizona became the 48th state. With the current boundaries firmly established such that the San Pedro River flows through two nations, the future health of the Basin will depend on coordinated management and mutual consideration of the many concerns on both sides of the border.

A United States military outpost was established in the Basin in 1877 for protection of the local citizenry and to maintain some effective control over the area. This outpost developed into Fort Huachuca, a modern military base for the US Army. The Department of Defense is therefore one more entity with which DOI must work closely in the course of managing water resources and administering its responsibilities in the Basin.

The Department of the Interior administers two unique land holdings in the Basin. In addition to the San Pedro Riparian National Conservation Area, established by Congress in 1988 and discussed earlier, Congress also designated the Coronado National Memorial to commemorate the exploration of the River by Francisco Vasquez de Coronado in 1540.

The remainder of the United States' portion of the Basin is either administered by BLM, the US Forest Service, the Department of Defense, or the state government of Arizona, or is in private ownership.

The Mexico portion of the Basin is mostly in private ownership, made up of several large ranches and ejidos (common lands). A large portion of this area is proposed as a "Protected Area of Wild and Aquatic Flora and Fauna" as part of the System of Protected Natural Areas in the State of Sonora (SANPES) which was implemented by the Governor of Sonora as part of the State Ecological Policy. A management plan has been written for the area (Secretario de Infraestructura Urbana y Ecologica, 1994). A map depicting the Basin is provided in Appendix A.

2. PHYSIOGRAPHIC PROVINCE AND TOPOGRAPHY. The Upper San Pedro River Basin lies within the Basin and Range Physiographic Province. Its headwaters begin in Mexico about 23 miles (37 km) south of the International Boundary and extends north to about 12 miles (19 km) north of Benson, Arizona. At this location there is a bedrock constriction across the valley known as "The Narrows." The drainage area of the upper watershed encompasses about 2,500 square miles (6,410 km^2), including roughly 700 square miles (1,795 km^2) located within Mexico.

The topographic ridge forming the western boundary of the Basin includes the Huachuca Mountains, Canelo Hills, Mustang Mountains, and the Whetstone Mountains. The eastern boundary is marked by the Mule Mountains, Tombstone Hills and Dragoon Mountains. These mountains range in altitude from 4,400 (1,341 m) to 9,500 feet (2,896 m) above sea level. The width of the upper valley varies from approximately 15 miles (24 km) to almost 20 miles (32 km), with an average alluvial floodplain width of almost 7000 feet (2,134 m).

The valley floor slopes gently from 4,800 feet (1,463 m) in Mexico to 3,300 feet (1,006 m) at "The Narrows," establishing a gradient of about 18 ft/mi., and creating a topographic relief within the upper drainage basin that ranges from 1,100 (335 m) to 4,700 feet (1,433 m). The river gradient drops to about 13 feet/mile where it flows through the San Pedro Riparian NCA.

3. CLIMATE. The climate of the Basin is arid to semi-arid. Due to its higher elevation, the Basin does not experience the extreme desert conditions which characterize neighboring areas. The climate is dominated by two annual rainy periods.

From July through September, convective orographic thunderstorms account for about 50-60% of the annual precipitation. Moist, tropical, unstable air from the Gulf of Mexico is forced over the southern slopes of mountains and is sufficiently cooled to cause afternoon storms of short duration, but high intensity, resulting in frequent flash floods.

During the winter, cyclonic fronts generated in the middle latitudes of the Pacific Ocean intensify off the California Coast and move east into Arizona. These gentle winter storms may last several days. Spring and fall are typically dry.

Annual precipitation averages about 15 inches at Fort Huachuca and about 11 inches at Benson. Higher annual averages occur in and near the mountains. Snow accounts for a relatively insignificant portion of total valley precipitation, but plays an important role in groundwater recharge near the mountains.

Winters are generally mild and minimum temperatures rarely fall below 10 degrees Fahrenheit. Summers are warm, with maximum temperatures normally in the middle 90's.

4. GEOLOGY: The mountains bordering the Basin are composed of granitic, metamorphic, volcanic, and consolidated sedimentary rock formations ranging in age from Precambrian to Tertiary. These units are generally of low permeability and porosity except where highly fractured.

The Basin is filled with sediments. The oldest unit is the Pantano Formation, a Tertiary conglomerate which is well cemented and has low permeability and porosity. This is overlain unconformably by late-Tertiary and Quaternary valley fill deposits consisting of well to poorly cemented clay, gravel, sand and silt, which serve as the main ground-water-bearing unit in the Basin.

The combined thickness of the Tertiary and Quaternary valley fill and the Tertiary conglomerates may be as thick as 5,000 ft. in some parts of the Basin. The Tertiary and Quaternary valley fill is divided into the upper and lower units. The upper unit ranges in thickness from a few feet near the river to about 620 ft. near Ft. Huachuca. The lower unit has a maximum thickness of about 1000 ft. in the middle of the Basin.

The valley is a structural trough, called a graben bounded by mountain ranges on the east and west which have been uplifted relative to the valley floor, along high-angle faults. The structural trough has been filling with sediments from the mountains to form the basin fill regional aquifer (Freethey, 1982). Directly overlying the Pantano formation, the St. David formation (upper and lower basin fill), consists of interfingered sand, gravel, silt, and clay beds. Along the river corridor, superimposed on the upper basin fill, lie younger (upper holocene) alluvial deposits that form the floodplain aquifer (Drewes, 1980; Freethey, 1982).

5. GEOMORPHOLOGY OF THE WATERSHED

Historical Influences. The present hydrologic system has been strongly shaped by historic events, both manmade and natural. Early Native Americans were the first to farm the fertile floodplain deposits along the river. They were followed by the Spanish, beginning with De Niza about 1539, then Coronado's expedition in 1542. However, the Spanish, for the most part, abandoned the San Pedro Valley after 1580. Spanish colonists then settled in the valley by 1686, but did not stay long because of Apache raids. There was very little permanent human occupation of the valley from the mid-1820s through 1875. It was not until the late-1870s that rapid settlement by Anglo cultures began (Wilkin and Galante, 1987). Fort Huachuca was established in 1877.

The rapid development which followed led to significant changes affecting the hydrology of the Basin. Trees from surrounding hills were cut for mining timbers, fuelwood, and to make charcoal for the smelters near Tombstone (Bahre and Hutchinson, 1985). Livestock grazing from 1539 through 1851, and later the reintroduction of large cattle herds in the 1870's accelerated rates of erosion and watershed degradation (Wilkins and Galante, 1987). Suppression of wildfires since the 1870's, the extinction of beavers by commercial fur trapping, and the practice of draining cienegas to control malaria have also drastically altered hydrologic conditions (Wilkins and Galante, 1987).

An earthquake on May 3, 1887 reportedly "shook the entire valley." This and other seismic activity in the area have undoubtedly caused changes in hydrologic conditions. Artesian

conditions in the Hereford and St. David areas may have been significantly affected as a result of that earthquake (Dubois and Smith, 1980).

Climatic changes have also had a great influence on regional hydrology. Large floods after the 1870's, which were preceded by lengthy drought, led to entrenchment of the river. Entrenchment occurred between 1890 and 1908 and changed the system from a surficial, sluggish cienega/marsh environment, to a faster, deeply incised river (Hereford, 1993).

Recent Changes Affecting the Watershed: Following the entrenchment period, the river widened between 1908 and 1955. After 1955, wet season oscillations changed from annual to biannual or longer, followed by a period (1957-1967) of above average low-intensity rainfall which allowed for better vegetative growth and improved ground cover, (Hereford, 1993).

Entrenchment was followed by proliferation of cottonwood-willow riparian forests, which serve as energy dissipators and slow down waters. River sinuosities also increased during this period, having a similar attenuative effect on rates of flow. Geomorphic studies show that widening has stabilized since 1955 (Hereford, 1993).

Since 1986, and following the creation of the San Pedro Riparian National Conservation Area, improved management practices have resulted in substantial revegetation of the floodplain and channel banks, with subsequent aggradation, stabilization, and increased fuel loadings. This can be attributed primarily to discontinuance of 1) livestock grazing, 2) sand and gravel mining, and 3) commercial crop irrigation; and to the effect of fencing and more restrictions on access within the NCA administered by BLM.

6. HYDROLOGY: THE CURRENT HYDROLOGIC SYSTEM. The overall watershed is probably in slightly better condition now than it was at the turn of the century (Hereford, 1993), but significant improvement could be achieved by following Best Management Practices. Streamflows are maintained by groundwater fed baseflows and vary seasonally in response to runoff from summer monsoons, and winter frontal storms. Water quality generally improves downstream and towards the inner valley (Brown and Caldwell, 1984). This picture is rapidly changing, however.

Hydrologic models and numerous groundwater studies show that the current rate of groundwater pumping (11,101,500 to 14,802,000 m^3/yr) threatens to deplete stream flows and destroy the riparian ecosystem. The quality of regional groundwater can also be expected to degenerate with continued declines in the water table. Perennial reach length in the river has shrunk in recent years below Charleston Hills.

Ground water: Groundwater studies completed by the US Army Corps of Engineers in 1970 showed that groundwater overdraft was creating a cone of depression in the Fort Huachuca/Sierra Vista area. Additional studies by Roeske and Werrel (1973), Harshbarger (1974), Konieczki (1980), Freethey (1982), Brown and Caldwell (1984), Putman et al. (1988), Rovey (1987), and U.S. Army COE (1987) have all confirmed that a significant cone of depression exists, is expanding, and has shifted its axis towards the river. The cone is now estimated to be at least 1.5 x 4 miles as it continues to grow.

Ground water modeling: The University of Arizona, Arizona Department of Water Resources, and other investigators have developed models to analyze groundwater conditions in the Basin. The models have been created with a simulation program called MODFLOW, a three-dimensional finite-difference groundwater model. Vionnet and Maddock (1992) updated MODFLOW with a "river package" enabling simulation of stream flow depletions by lowered water tables and cones of depression. Earlier versions assumed a constant supply of river flow, regardless of groundwater levels. In addition, Vionnet and Maddock (1992) modeled the alluvial aquifer, omitted in earlier versions.

Based on their updated model, Vionnet and Maddock (1992) concluded: "Simulation shows aquifer storage losses increase continuously; pumping at same rate (1988 levels) will dry up the river within 20 years; base flows lost. Based on available information, water levels will drop below streambed elevations within 20 years. A five to seven foot {1.52 to 2.13 m} negative change in alluvial river cells can be expected in that same time-frame. The model cannot achieve a steady state, indicating no gaining stream reaches will be left. Capture is already occurring from the stream system to offset regional and alluvial pumpage. Streamflow gains were reduced drastically over the 48 year simulation period...."

Dr. Rovey (1987), using MODFLOW along with her own model, also performed a Theis well field simulation and a Glover stream depletion analysis, all with similar conclusions.

The problem is not one of simply balancing a water budget for the Basin. It is much more complex than that. Concentrated overdrafting between the mountain-front recharge zone and the last remaining perennial reach of the river, is cause for concern. However, the total amount of groundwater stored in the Basin does not represent the quantity of water available from only one portion of the aquifer. Many localized environmental impacts and economic restrictions may be encountered long before total aquifer storage is exploited.

As pumping continues, risks of land subsidence and earth fissuring, which often occur in areas of extensive groundwater mining, could be substantially increased. Eventually, continued concentrated groundwater mining will jeopardize sustainable yields of potable water and long-term economic stability.

B. BIOLOGICAL ASPECTS

The Upper San Pedro River Basin is world renowned for its floral and faunal resources. The Basin and its resources have received much attention from environmentalists, planners, land managers, researchers, politicians, and the public in general.

Numerous studies have been conducted and there is a large volume of data concerning both the biological and physical aspects of the Basin. There are several reports that have summarized the biological resources of the whole Basin, or portions of the Basin (see Appendix D). These studies and reports are both extensive and intensive in nature. A number of additional studies are underway in the Basin as of this writing.

National and international interest in the Basin has been generated due to its combination of natural and cultural resources, and areas such as the San Pedro Riparian National Conservation Area managed by BLM, the Nature Conservancy's Ramsey Canyon Preserve, Coronado National

Memorial, Coronado National Forest, and Ft. Huachuca. These designated areas support diverse biological assemblages and attract many visitors.

Biotic communities, or biomes, are often used as basic elements of mapping and describing the biological elements of a landscape. Biotic communities are regional plant and animal associations within larger biotic provinces (Brown et al. 1995). Biomes are ecosystem based and follow Merriam's (1890, 1898) life zone notion and that of biotic provinces (Dice 1943). Dice's biotic provinces have been revised by Bailey (1976, 1978) and called ecoregions (Lowe and Brown 1982).

Biomes have been described as having a distinctive evolutionary history and tend to be centered in particular geographic regions (Brown et al. 1979). Biomes are natural formations which are characterized by a particular vegetation physiognomy within a larger biotic province (Lowe and Brown 1982). Lowe and Brown (1982) state further that the limits of a biotic community are determined by climate. The local boundaries of a biotic community may be affected by elevation, slope, exposure, cold air drainages, soils, and other factors (Lowe 1964:84-91, Lowe and Brown 1982).

The variety of biotic communities found in the Basin and the associated diversity of plant and animal life is due in part to the variation in topography and physiography found in the Basin and the juxtaposition of four biogeographic provinces. The Chihuahuan and Sonoran biogeographic provinces meet on an east-west axis and the Southwest Interior and Madrean provinces converge on a north-south axis (Brown et al. 1995). In addition, two of the worlds' seven biogeographic realms (Neartic, Neotropical) and three of the four climatic zones occur in the area. The fourth climatic zone occurs within 50 miles (80 km) on the Pinaleño and Chiricahua Mountains.

No basin-wide vegetation type or biotic community surveys have been completed as of this writing. However, as part of the Semi-Arid Land-Surface-Atmosphere Program (SALSA--See Section V.B.), the Environmental Protection Agency (EPA), Environmental Sciences Division(See Section V.H.), is preparing digital land cover maps based on Landsat-MSS imagery that will classify vegetation types in the United States and Mexico portions of the Basin. This effort will result in vegetation maps using a modification of the Brown et al. (1979) classification system, and maps will be produced for the 1970s, 1980s, and 1990s to allow analyses of vegetation change. These maps will be available on the EPA's San Pedro River Project website at http://www.epa.gov/crdlvweb/land-sci/san-pedro.htm.

Existing information on the biotic communities that are known or suspected to occur in the Basin come from a variety of sources. Vegetation types of the San Pedro Riparian National Conservation Area have been mapped following Brown et al. (1979). Using a different system, Ohmart (1979) mapped riparian vegetation types from the International Border to the Gila River. The Arizona Department of Water Resources also mapped riparian vegetation for the United States portion of the river, including the San Pedro Riparian National Conservation Area (ADWR 1991). Vegetation type surveys and mapping have been conducted on the Coronado National Forest (Tom Deecken, pers. comm.) and Fort Huachuca (NRCS and DOD 1996). The Natural Resource Conservation Service (NRCS) identified and mapped vegetation types and ecological sites on Fort Huachuca and grouped them into Brown et al.'s (1979) biotic communities. They also list physical attributes, common plant species, and natural fire regimes of each biotic

community on the Fort (NRCS and DOD 1996). These and other sources, in addition to personal observation, were used to assemble the list of known or potential biotic communities in the Basin.

Twenty-two biotic communities are known or have the potential to occur in the Basin (Figure 1). In addition, biotic communities within the Sonoran biogeographic province potentially occur in the northern end of the Basin. There are eight known or potential upland biotic communities in the Basin. Table 1 shows the upland communities and their relationships within Brown et al.'s (1979) classification system and to biogeographic provinces. The 1979 publication has been updated twice. The first being a Desert Plants publication (Brown 1982a). The second, published by the University of Utah Press, was a slightly revised reprint of the Desert Plants publication (Brown 1994). The riparian and wetland biotic communities are too small to show up on most maps, and specific surveys of these sites must be conducted to identify them.

Prior to 1988, three hundred and three species of birds, 84 mammals, and 41 herptiles were identified in the Basin in the United States (BLM, 1989). Due to changes in management along the river, the number of bird species have increased to more than 400.

Historically, 13 species of fish were present in the United States' portion of the river. Of those, two remain; the longfin dace and the desert sucker. Currently, most of the fish in the River are non-native species. At least 14 species are found in the Upper San Pedro River or its tributaries in the United States (BLM, 1989).

122.3	Petran Montane Conifer Forest - Brown 1982
122.6	Madrean Montane Conifer Forest - SIUE
123.3	Madrean Evergreen Forest & Woodland - Brown 1982
133.3	Southwest Interior Chaparral - NRCS and DOD 1996
142.1	Plains Grassland - Brown 1982
142.4	Rocky Mountain Montane Grassland - Deecken, pers. comm.
143.1	Semidesert Grassland - Duncan 1988
153.2	Chihuahuan Desertscrub - Duncan 1988
222.3	Rocky Mountain Riparian Deciduous Forest - Szaro 1989
222.5	Madrean Montane Riparian Deciduous Forest - NRCS and DOD 1996
223.2	Interior Southwest Riparian Deciduous Forest & Woodland - Duncan 1988
232.3	Rocky Mountain Riparian Scrub
233.2	Interior Southwest Swamp & Riparian Scrub - Duncan 1988
242.4	Rocky Mountain Marshland
243.3	Chihuahuan Interior Marshland - Duncan 1988
243.5	Madrean Marshland
252.4	Rocky Mountain Stream & Lake Strand
253.3	Chihuahuan Interior Strand - Brown 1982
253.5	Madrean Stream & Lake Strand
262.4	Rocky Mountain Montane Submergents
263.3	Chihuahuan Inland Submergents

Figure 1. Known or potential biotic communities of the Upper San Pedro River Basin, United States and Mexico, number and name (Brown et al. 1979), and data source.

Table 1. Upland biotic communities of the Upper San Pedro River Basin, United States and Mexico, and their relationship to other classification levels. Adapted from Brown et al. (1979) and Brown et al. (1995).

Level	Hierarchy							
Biogeopraphic Realm 1,000[1]	NeartIc (1000)[2]							
Formation Type 10[1]	Forest & Woodland (20)			Scrubland (30)	Grassland (40)			Desertland (50)
Climatic Zone 1[1]	Cold Temperate (2)		Warm Temperate (3)		Cold Temperate (2)		Warm Temperate (3)	
Biogeographic Province	Rocky Mountain	Madrean		Southwest Interior	Plains	Rocky Mountain	Chihuahuan	
Biotic Community 0.1[1]	**Petran Montane Conifer Forest (122.3)**	**Madrean Montane Conifer Forest (122.6)**	**Madrean Evergreen Forest & Woodland (123.3)**	**Interior Chaparral (133.3)**	**Plains Grassland (142.1)**	**Rocky Mountain Montane Grassland (142.4)**	**Semidesert Grassland (143.1)**	**Chihuahuan Desertscrub (153.2)**

[1] The numbers refer to the numbering system of Brown et al. (1979).
[2] Neotropical biotic communities (Sonoran) of each formation type may occur in the northern end of the upper basin. They do occur in the Lower San Pedro River Basin, and to the west and south.

Special Status Species and Communities

Special status species of the Basin are listed in Table 3 in Appendix C. Included are species listed as threatened or endangered under the US Federal Endangered Species Act, candidates for Federal listing, and species included in the Arizona Game and Fish Department's draft list of Species of Concern. Species of the Basin designated by the Secretaria de Desarrollo Social, Mexico (1994) as in danger of extinction, threatened, rare, or those species subject to special protection in Mexico are listed in the appendix to the management plan developed by Mexico's Secretary of Urban Infrastructure and Ecology (SIUE, 1994). Many species on the Mexican list are common or widespread in Arizona and are not considered threatened or endangered in the United States, such as Arizona walnut, mule deer (*Odocoileus hemionus*), and common kingsnake (*Lampropeltis getulus*), all listed as threatened in Mexico. Other listed or protected species that occur in the Mexican portion of the Basin are not known to occur in the US portion of the Basin. For instance, SIUE (1994) lists the green toad (*Bufo debilis*), Gila monster (*Heloderma suspectum*), desert tortoise (*Gopherus agassizii*), and Sonora sucker (*Catastomus insignis*) for the Mexico portion of the Basin, but these species are not known to occur in the US portion of the Basin.

Some of the species in Table 3, Appendix C, are particularly important because they are federally listed and therefore have an important influence on environmental decision-making, particularly at the Federal level. Other species are unusual because they are rare, sometimes at the northern edge of their range, and some biotic communities in the Basin are very diverse, often supporting many of these unusual or rare species. Some of these species and highly diverse communities also have high recreation value. This is especially true of specific avian species such as hummingbirds and elegant trogons, and areas rich in unusual species, such as the San Pedro Riparian NCA and Ramsey Canyon. These species and areas attract bird watchers and ecotourism which have contributed significantly to the local economy (Crandall et al. 1992). Some of the more important species and communities in regard to environmental decision-making and the economics of tourism are highlighted in Appendix C.

In Mexico, in or adjacent to the Basin, 262 species of vertebrates have been found, including 117 species of birds, 65 mammals, 58 reptiles, and 15 amphibians (Secretario de Infraestructura Urbana y Ecologia, 1994).

C. SOCIOECONOMIC ASPECTS

Most of the United States portion of the Upper San Pedro River Basin is located within Cochise County, Arizona. However, portions of the Babocomeri tributary are located in Santa Cruz and Pima Counties, Arizona.

In 1995, according to the Arizona Department of Commerce (1996), 112,300 people resided in Cochise County, of which 37,815 lived in Sierra Vista.

About 40 percent of the County is private land, while 35 percent is owned by the State of Arizona and 22 percent is administered by the US Forest Service and the Bureau of Land

Management. An additional three percent is in other public ownership. (Arizona Department of Commerce, 1996).

Fort Huachuca and other government offices provide the most opportunities for employment in the County. Trade and service organizations also are large employers. Cochise County continues to have importance as a producer of agricultural crops and livestock. Other significant categories of employers include manufacturing; construction; and transportation, communication and utilities. Fort Huachuca Army Base is one of the largest civilian employers in Arizona.

Most of the land in the Basin is used for agriculture and livestock ranching (Lacher, 1994). Tourism is an expanding business, with attractions such as Tombstone, Fort Huachuca, Coronado National Memorial, Ramsey Canyon, San Pedro Riparian National Conservation Area and Karchner Caverns (expected to be opened to the public in the near future).

Real estate development is increasing in the vicinity of Sierra Vista as more people are attracted to the mild climate and new economic opportunities become available.

For further information regarding the demographics of the Basin, contact the Arizona Department of Commerce or the Arizona Department of Economic Security.

IV. EXISTING DATA AND INFORMATION

A. EXISTING GIS DATA SETS

Geographical information system (GIS) data sets for the San Pedro Riparian National Conservation Area include ownership, transportation, boundaries, public land status (township, range, and section), hydrography, towns, surface geology, geologic faults, vegetation, grazing allotments, threatened and endangered species, watersheds, Arizona Game and Fish Department Management Units, and soils. Information on these data sets is available at the BLM San Pedro Project Office in Sierra Vista, the BLM Tucson Field Office in Tucson, and the Arizona State Office in Phoenix, Arizona.

Other DOI bureaus, Federal and State agencies and nongovernment organizations have additional GIS data on one or more of the above themes as well as other themes.

B. EXISTING REPORTS AND PUBLICATIONS

As stated previously, the Basin has been of interest to numerous federal and state agencies, nongovernment organizations and individuals for many years. Numerous reports and publications have addressed natural resource issues in the Basin. The USDA Agricultural Research Service produces a bibliography of available publications for its Southwest Watershed Research Center (located within the Basin) related to its work and mission. Each year's work, beginning in 1959, is listed in alphabetical order by author along with an abstract. The list is updated yearly.

Appendices D and E of this report provide an initial listing (albeit incomplete) of reference materials. Mr. Doug Duncan and Mr. Jim Rorabaugh, US Fish and Wildlife Service, have compiled the bulk of the bibliography of biological resources in Appendix D. Other contributions have been added. Mr. Richard A. Trapp, Arizona Geological Survey, and Ms. Brenda Houser, US Geological Survey, have compiled the bibliography of geology and hydrology of the Upper San Pedro River Valley in Arizona and Sonora in Appendix E. Their bibliography has been expanded by references provided by Mr. Paul Summers, BLM National Applied Resource Sciences Center, and others.

C. STAKEHOLDERS

A preliminary list of governmental (federal, state and local) agencies, and organizations interested in the Basin is provided in Appendix F. Additionally, there are numerous landowners and individuals in the United States and Mexico that have an interest in actions being considered in the Basin.

D. ISSUES FROM THE DOI MANAGEMENT PERSPECTIVES

1. MANAGING BASIC CONFLICT.

The task facing resource managers and land management administrators in the Upper San Pedro River Basin is one of managing basic conflict. The demands and pressures imposed on the Basin are inherently in conflict and reflect the desire and need to provide access to the abundant resources on one hand, and to protect them from overuse on the other. In many cases it may be possible to accommodate both use and protection, but only if we come to understand the issues in the context of the Basin as a whole, rather than as separate, site-specific problems. To accurately determine what the real issues are, it is necessary to understand the complex interrelationships that operate in the Basin, and to recognize the biological thresholds and environmental constraints that determine the continued health of the Basin and the survival of its living components.

Science and engineering can provide managers with better information and improved tools to assist them with successful issue resolution. Although our scientific knowledge is never complete or perfect in any field, scientific analysis based on reliable data is still the critical element in our effort to predict the consequences of our actions. Politics, public opinion and emotion may enter into decisions, but they are poor predictors of successful long-term outcomes. It is only with objective science, however imperfect it may be, that we can have some confidence that the decisions made today are ecologically sound, and that the management options that are presented to us represent reasonable, environmentally acceptable choices. Science in this case is not just an extensive accumulation of data or series of studies and reports, but is the management and use of that data to identify, characterize, and resolve real, on-the-ground natural resource problems. It is an objective process that leads to supportable on-the-ground management decisions. The process entails sorting a genuine problem from the myriad of public and political opinion, analyzing the problem and determining its causes, then identifying realistic responses that are based on proven historical methods and hard, scientific facts. Finally, it is important to recognize both the positive and negative affects of planned action, and to consider the costs associated with successful completion.

Many of the pressures confronting managers in the Basin can be reduced to a basic clash between social and environmental priorities. Simply put, how does one balance the use of the natural resources in the Basin to sustain local economies (allowing people to earn a living), with maintaining viable habitats needed for plants and animals to survive and flourish, and also accommodating the scientists and visitors who are drawn to the Basin specifically because of its unique values and bio-diversity?

The Department of the Interior is involved in the Basin on several levels. The resource management agencies (BLM and NPS) have direct day-to-day administrative responsibilities for a variety of resources or special management units. On one level, they may be facing immediate problems that are occurring within their areas of administrative responsibility in the Basin. On another level they may be administering national initiatives and programs that are applicable to their areas of responsibility, but are not an issue in the Basin. On yet another level, science agencies within DOI (e.g., BOR, FWS, and USGS) may be conducting research, collecting data, or performing studies and projects in the Basin.

As a result, when we talk about DOI concerns in the Basin, it is necessary to segregate them into existing issues that need urgent attention; potential problems known to exist elsewhere under similar conditions, but not firmly established as a problem in the Basin; and broad, national responsibilities that need to be considered in the Basin as they do in all areas of agency jurisdiction. In the following sections, the interests that DOI has in the Basin are simply divided into two groups: those that are urgent and require immediate attention, and those that are relevant and require further consideration.

2. PRINCIPAL EXISTING ISSUES OF CONCERN TO DOI (urgent and require immediate attention)

a. Access vs. Resource Protection. The growing popularity associated with the unique resources in the Basin has brought mounting world-wide public pressures for access to the area for study or to simply observe the unique features and resources of the Basin. This demand for greater access stands in direct conflict with the need to set some areas apart or restrict access to protect the characteristics that make them unique.

b. Education. Most of the environmental problems in the Basin are a consequence of human activities. In the past, we have taken actions, utilized natural resources and made long-term changes with little or no realization of how our actions, or the natural systems in the Basin, are interconnected. Today we recognize that such relationships exist and are fundamentally important, but we still lack an adequate understanding of how it all works and fits together. There is a need for better education on two fronts. Technical resource specialists and managers must learn much more about the resources and systems they manage so that future decisions are based on good science. Secondly, the communities, private entities, residents and visiting public must be made aware of the unique environmental values that exist around them, of the risks facing these resources, and the role that they collectively play in assuring the long-term survival of these local, regional and international assets. Some of the areas that require a particular educational emphasis include:

Riparian functions - Our understanding of the San Pedro riparian system is inadequate. The public does not understand the importance of riparian systems, or the relationship of healthy ecosystems to their own well-being. As a result, support for the preservation of the riparian area is not as strong as it could be. The NCA is viewed as a consumer of large quantities of water under the same adverse circumstances that require water conservation to be imposed on the general public. This creates a hostile political environment for DOI in its attempts to secure adequate quantities of water to maintain a healthy NCA. It is in the interest of DOI to educate the public on the critical role of riparian areas, and to increase their awareness and understanding of the benefits that accrue to them as a direct result of the National Conservation Area.

Ecosystem interaction - Riparian areas are only one of many components, albeit a complex and critical one, that comprise the larger ecosystems in the Basin. Some of

these ecosystems are unique. Efforts to expand our scientific knowledge and educate the public, as discussed for riparian areas, must also deal with the broader issues of land use in the Basin and its implications to ecological relationships. As resource managers, we are handicapped by a general lack of understanding of the complex interactions at work within the larger ecosystem and how our individual decisions affect the whole. From the U.S. perspective, it is particularly important that we learn more about the response of these systems to actions and events that take place in the upland area of the Basin that is within Mexican jurisdiction.

Ground water/surface water interactions. The hydrologic relationship between groundwater and surface water in the Basin is not well understood, which hampers effective management and decision-making. Managers need to know more about how the pressures exerted on each system alone affect the other. As our understanding increases, it is important to share this knowledge with the communities, public and private entities, and residents who produce or use the dwindling water resources. In order to develop effective strategies for managing these valuable resources in the future, they must become informed partners and recognize how the practices of each affect the others. The problem of diminishing water supplies will be resolved only if all stakeholders work collaboratively to modify their practices, based on accurate information and sound science.

c. Resource Protection.

Preservation of archeology and historical sites The Upper San Pedro River Basin has a rich history of Native American occupation and use, Spanish exploration and early settlement by Mexican and Anglo cultures. Known archeological and historical sites contain a wealth of irreplaceable information about these early people, their culture and lifestyles, and the events that shaped their future and our past. Known sites are likely to reveal much more as these fields of study evolve. Of equal or greater importance, it is likely that many sites, artifacts and clues to the past remain as yet undiscovered, perhaps holding new information and critical clues about the Basin's past. DOI has a moral and statutory obligation to ensure that such sites and the information they contain are not lost through careless or irresponsible decisions, or illegal actions. Paleontological sites also exist in the Basin.

Protection of Unique Plants and Animals. The increase in public interest and visitation has made it increasingly difficult to protect those values and resources that draw people to the Basin in the first place. Some of the threatened and endangered riparian plants and animals in the area are particularly at risk. The Huachuca water umbel and the southwestern willow flycatcher are two examples (see Appendix C for a discussion of these and others). The Department of the Interior has been given charge of their protection and must find ways to accomplish this without unnecessary infringement on the rights and desires of the public for reasonable access.

d. Water Resources.

Depletion of Ground and Surface Water Supplies. As illustrated in the earlier discussion of the Basin hydrology, over-pumping is a serious problem with serious implications for the Basin ecosystem as a whole. Over-pumping causes disruption and interception of water that would normally recharge Basin ground water and eventually decreases surface water in the river itself. The problem is widely recognized and has received considerable media coverage for three decades. Studies and actual production history indicate that it could only be a matter of time before the depletion of groundwater dries up the river in the National Conservation Area. Because DOI has the responsibility for managing and protecting resource values in the National Conservation Area, which depend on the surface water in the river, the issue of over-pumping must be quickly and permanently resolved. This, in turn, requires a better understanding of the relationship between groundwater and surface water interactions.

Recent evidence suggests that the groundwater depletion that poses a direct threat to the National Conservation Area is the result of the cumulative demands of three principle water user groups. One is the agricultural community, which utilizes water for irrigation. Second is the group of expanding urban centers which must meet an increasing demand for groundwater created by the growing population centers in the Basin. The third is Fort Huachuca. The role of Fort Huachuca in this issue has the attention of both the Department of Defense and the Department of Justice, and presents opportunities for partnerships that could be mutually advantageous. DOI is affected by the decisions made at Fort Huachuca, and should contribute to any potential Environmental Impact Statements produced and should assist in the analysis of impacts of their decisions. Arguments presented by the Department of Justice in support of the Fort's water rights will have a correlative impact on similar Federal water rights held by DOI.

The Gila River Indian Community also asserts a right to flows in the Gila River, which is fed by the San Pedro River. Their case is complicated by numerous surface water diversions and conflicting water rights on the San Pedro and the Gila Rivers. The Gila Indian water rights are fulfilled by both surface water diversions and groundwater withdrawals in the Upper San Pedro River Basin. In order to fulfill the Gila Indian water rights, pumpage in the Basin must be managed to prevent loss of surface flows due to capture of ground water recharge that provides base-flow to the San Pedro River. Water quality is an associated issue that is addressed below.

Water Rights Adjudication. A general stream adjudication of the Gila River system began in 1978 in the San Pedro River Sub-basin with a petition to the state by American Refining and Smelting Company to resolve conflicting water rights. Claims were filed and data were collected until the publication in 1991 of the Hydrologic Survey Report by the Arizona Department of Water Resources (ADWR). The massive Hydrologic Survey Report catalogued over 8000 claims for water, evaluated all uses, proposed a water budget and in the process raised nearly as many issues as it

resolved.

One of the important issues raised by the adjudication was how to draw the line between surface water and groundwater that has been created, but poorly defined, by Arizona law. Surface water must be appropriated, and uses must not interfere with those of senior, or prior appropriators. However, in most of the rural areas of the state, including the Basin, groundwater does not require appropriation. The prospective pumper needs only to notify ADWR of the intent to drill a well. As activity in the adjudication increased in 1992, a growing body of reliable data showed foreseeable, near-term impacts of groundwater pumping on San Pedro River surface water rights. The adjudication judge, Stanley Goodfarb, was compelled to draw a reasonable, legal line between surface water and groundwater. No more sincere effort to reconcile Arizona law and physical reality has been made than Judge Goodfarb's. After several years of hearings and deliberations, the "line" was moved from the stream channel itself out to where the floodplain alluvium ends and the older, basin alluvium begins. Despite the work by hydrologists, modelers, and the court, the connectivity between the regional aquifer of the basin and the San Pedro River surface flow will remain unrecognized under state law. The judge's resolution of the issue is still under appeal.

An explicit federal reserved right to enough water for BLM to fulfill the purposes of the San Pedro Riparian National Conservation Area was granted by Congress in 1988. Case law suggests that the federal reserved right for surface flow in the National Conservation Area could be protected from junior groundwater pumping (Cappaert v. U.S., 1976). Whether the Cappaert precedent will apply to the San Pedro River where numerous, dispersed groundwater pumpers have been slowly creating an impact is uncertain.

The Gila River Indian Community is also a claimant in the San Pedro Sub-basin adjudication. Although their place of use is far downstream on the Gila River, they contend that all water in the Upper San Pedro River Basin contributes to the flow of water to their reservation, and is included in their very senior claims. They have filed objections to all other claims in the San Pedro River Basin. The Gila River Indian Community is unlikely to receive all the water they have claimed, but their claims and objections are a cause for concern among Basin users. Protecting the surface flow (including the subsurface flow) in the National Conservation Area also protects the rights of the Gila River Indian Community, and vice versa. The Gila River Indian Community claims have contributed to motivating major water users in the Basin to join in negotiating a settlement on claims and uses with BLM, Fort Huachuca and other federal interests. At this time, however, the Gila River Indian Community is declining to participate in the negotiations, which are inactive.

Other than providing incentive for negotiation and recognizing senior downstream claims by the Gila River Indian Community, the adjudication is unlikely to provide protection for the river's surface flow from current water users. BLM claims are junior to most others, and much of the use is unappropriated groundwater pumping. DOI's strategy could concentrate on those few helpful aspects of the adjudication, as

well as educating the local community about the economic and "quality of life" benefits of a healthy San Pedro River. DOI and DOD could also cooperate with the state and local water users in finding and supporting ways to reduce over drafting of groundwater and balance the water budget of the Basin. Decline in use by the growing community of Sierra Vista is unlikely. Therefore, new water must be added to the budget. New water could come from interbasin transfer, or increases in groundwater recharge. About 3.5 million acre-feet of precipitation falls on the watershed annually, but only about 1.6 percent leaves as streamflow and less than 0.5 percent is recharged (ADWR, 1991). Finding opportunities for even small increases in percentage of recharge could be very productive. Work on small scale recharge projects is already in progress with studies by the Army on detention basins along the mountain front, and effluent recharge by the city. However, these are often expensive or politically sensitive alternatives. For all of the good intentions of many parties, the future of the San Pedro River surface flow and rich riparian ecosystem in the National Conservation Area remains at risk.

Water Quality. Twenty eight percent of the Basin, including all of the headwaters, falls within Mexican jurisdiction. Contamination of the San Pedro River in the upper part of the drainage can affect downstream water users. Sources of pollution on the United States side of the border are subject to a host of laws and regulatory entities. Any pollution originating on the Mexican side of the border presents an entirely different set of political, legal and policy issues for the United States that must be sorted out in a collaborative fashion. One example of a more immediate concern is pollution from under-treated sewage caused by the occasional flooding of the sewage treatment area in Naco, Sonora, which results in the discharge of untreated contaminants and a rise in fecal coliform in the San Pedro through Green Bush Draw. This concern, however, is in the process of being mitigated. See Section V.F.

Another potential source of pollution below the border is acid mine drainage (discussed below). Increases in organic wastes and coliform pollution, or abrupt changes in water chemistry or pH can pose a direct threat to the biota in the National Conservation Area. It is therefore in the best interest of DOI to take an active role in assisting Mexican communities to improve the infrastructure for wastewater treatment and isolation and stabilization of mine waste.

Groundwater/Surface Water Interactions/Water Budget/Accounting. The laws of groundwater use in Arizona notwithstanding, there is little doubt that the saturated basin fill is an integral part of the groundwater/stream flow regime in the Basin (Jackson, et al., 1987). Groundwater contributions to San Pedro River flow are from 1) basin fill, and 2) underflow within the floodplain aquifer which originates in Mexico. Contributions from basin fill are more than four times the groundwater inflow from Mexico (ADWR, 1991). According to ADWR, significant contributions to flow are also made by inflowing surface water from Mexico and San Pedro

tributaries. Ninety percent of the groundwater recharge results from percolation into sediments along the mountain fronts (ASL, 1995) and most of the rest results from percolation into drainages that have incised into basin sediments. Groundwater moves downgradient through porous basin fill sediment from the mountain fronts that surround the upper basin. Clay lenses scattered through the basin sediments restrict vertical hydraulic conductivity as the groundwater moves laterally toward its discharge point in the San Pedro River.

The Hydrologic Survey Report included a water budget that estimated the total recharge in the Basin, inflows, outflows, and depletions. ADWR estimated that the annual groundwater storage overdraft at about 9000 acre-feet. At this rate the estimated decline in the regional aquifer is 0.5 to 1.0 feet per year. Other investigators have estimated that the cone of depression caused by groundwater pumping in the Sierra Vista area may be deepening at rates as high as 5 feet per year or more (ADWR, 1991). Resulting projections of when the overdraft will directly affect the San Pedro surface flow vary from immediately to fifty years in the future. A broad variety of research on water use and movement in the Basin continues to improve understanding of the hydrologic system. For example, recent work by Agricultural Research Service hydrologists is providing a wealth of new information about evapotranspiration rates of the San Pedro riparian vegetation communities. Some work suggests that earlier estimates of evapotranspiration and groundwater use by riparian vegetation may be high (Scott, et al., 1998). Another recent SALSA paper estimates total evapotranspiration of the riparian corridor from Lewis Springs to Fairbank to be considerably higher than earlier ADWR estimates (J. Qi, et al., 1997). Other investigators have found that ADWR calculations of cultural uses may be high. As research and modeling continue, the complete picture of the Basin water budget will be clarified.

e. Mining.

Acid Mine Drainage. Overflow, leakage and tailings dam failures at the copper mining operations in Cananea, Sonora, associated with excessive runoff, impacted the river in Mexico and the United States on several occasions in 1977-79 (Eberhardt 1981; Jackson, et al, 1987). The acidic water impacted the river for a minimum of ten days and the river remained acidic for some time. A spill in 1979 resulted in water that was brick-red in color, a pH as low as 3.1 and dissolved oxygen as low as 2.0 mg/l, in addition to high iron, copper, manganese, zinc, and suspended solids. Aquatic life in the river was killed (Jackson, et al, 1987). The potential for a recurrence of events such as these are of great concern to DOI. Such occurrences pose severe threats to plants and animals in the San Pedro Riparian National Conservation Area and downstream.

BOR has considerable expertise in dam safety that could be offered to Mexico. For example, its experts could assist in training and oversight in the inspection and maintenance of structures, and assist with development of an Emergency Action Plan for the tailings dams in the Basin. The benefits of such cooperation accrue to both

countries.

Abandoned Mine Lands. The Bureau of Mines identified, and sealed the entrance to several abandoned mines in the Basin. The closures were done in a way which allowed for their continued use by bats, which had come to depend on the man-made caves as essential habitat. With the elimination of the Bureau of Mines in 1995, this work needs to be reassigned within DOI. Both BLM and the National Park Service have active programs for locating and eliminating hazards often associated with abandoned mines on public lands. Abandoned mines are widespread on the public lands. Many present safety hazards to an unsuspecting public. Others pose serious health and environmental risks through leaching of heavy metals, acid drainage, or the presence of hazardous materials.

Although materials from many abandoned mines on the public lands are benign, past mining activities at other sites have contaminated thousands of acres and severely impacted streams. The potential for either safety hazards or health risks from abandoned mine lands within the Basin is real, as evidenced by the mine sites that have already been sealed and the tailings dam failure at Cananea. However, the potential extent of abandoned mine land concerns is unknown, and will require an active inventory effort to determine. As visitation and interest in recreation use continues to grow within the Basin, the opportunity for serious injury or death at abandoned mine land sites also rises. It is important that DOI continue inventory efforts, which will enable agencies to identify and eliminate the mine hazards that pose the highest risks.

3. ADDITIONAL ISSUES, CONCERNS, OR INITIATIVES INVOLVING DOI (relevant and require further consideration)

a. Border Withdrawal. The Basin is about 35 miles wide where the United States-Mexico border bisects it. On the United States side, the land immediately adjacent is administered by several jurisdictions (BLM, NPS, US Forest Service, State and private). On May 27, 1907, President Theodore Roosevelt issued a Proclamation (35 Stat., 2136-2137) establishing a withdrawal along the entire Mexico border. This withdrawal set aside a strip of land 60 ft. wide for the full length of the boundary line between the United States and the Republic of Mexico. This strip was to be kept free from obstruction and used only for public highways. However, the Proclamation did not assign responsibility for administration of the strip to any agency. Where the withdrawal is located on BLM land, BLM has been administering the withdrawal, as well as the land. The issue of administrative authority arises on those segments of the border withdrawal that exist as a reservation in patents to individuals, are on State government land or that cross other federal agency land. The strip is utilized by the Border Patrol, Immigration and Naturalization Service and other federal and state law officials. The law officials need to work in partnership with the appropriate land manager. The International Boundary and Water Commission also has vital interests in this withdrawal area, but claims no responsibility for its administration. The Federal Land Policy and Management Act

requires BLM to review this withdrawal and make recommendations concerning its continuance.

b. Desertification. Desertification is a natural process that occurs in the transition zones at the edges of many desert environments. It represents an expansion of the desert-like ecosystems into neighboring areas, and a corresponding change in, or loss of, previously existing vegetative cover and faunal associations occurring in those areas. Although desertification is a response to natural changes in climatic and hydrologic conditions, the process also can be triggered or exacerbated by human activities in an already arid, semiarid or dry subhumid area. Historical baseline data makes it possible to interpret present conditions, to determine natural variability, to predict susceptibility to future change, and to recognize the true signals of desertification and associated causes.

A carefully designed monitoring program would be a first step to determine to what extent desertification is taking place. The United States Geological Survey (USGS) is trying to secure a station in the Basin in conjunction with their Desert Winds Project. Wind erosion can leave clues about past climatic episodes. Desert Winds is a project to monitor climate-sensitive surfaces in the southwest United States and use what is learned about current processes to help us accurately interpret the climates of the past. If successful, the project could help us detect indicators of increased aridity or desertification, or establish that it is not occurring.

Additionally, the US Environmental Protection Agency is using the Basin as a case study to develop a multi-scale, multi-temporal method for evaluating ecosystem management and assessing ecological condition in borderland watersheds. The emphasis of this case study is the assessment of land degradation and habitat suitability for selected wildlife species (Kepner 1996). See Section V.G.

c. National Environmental Policy Act Compliance. The requirements of the National Environmental Policy Act (NEPA) touch all federal agencies and their actions. Every proposed action that federal agencies consider must be reviewed in compliance with the Council of Environmental Quality regulations that implement NEPA. In the Basin, several DOI bureaus have compiled NEPA documents, including land use plans, that need to be reviewed in the context of an overall DOI perspective. BLM, for example, completed the Final San Pedro River Riparian Management Plan and Environmental Impact Statement in June 1989.

d. Resource Management Planning. Use authorizations and on-the-ground management practices must conform with the resource management plan that applies to the public lands involved and planning regulations. Plan amendments may be prepared to address proposals that don't conform. As knowledge of the Basin grows and the complex interrelationships begin to be understood, it will be important to reflect that new knowledge in planning documents and in the resource management decisions that are based on them. In other words, new knowledge must be consciously incorporated into the way business is conducted, and not simply placed on a bookshelf.

e. Salinity. Actions taken by BLM to contain salt on the San Pedro River would have no effect on the big municipal water users of Colorado River in the United States, as the last of the large diversions for municipal water users are at Parker Dam (Central Arizona Project and the Metropolitan Water District at Lake Havasu). The same can be said of agriculture diversions, as the last major irrigation diversion comes off at Imperial Dam, above the Gila confluence. However, there is a Yuma Desalinization Plant that lies dormant along the Colorado River, below the Gila confluence. Salinity produced in the San Pedro River would be removed if the Yuma Desalinization Plant were reactivated. There have been discussions in the past between Mexico, the International Boundary and Water Commission, and the Bureau of Reclamation regarding the average annual variation of salinity levels in Colorado River water deliveries at the international boundary west of Yuma. However, the future of the Desalinization Plant is uncertain.

f. Soils. In 1986-87, the Natural Resources Conservation Service, under contract with BLM, completed a soils inventory (standard Third Order Survey) that included the Upper San Pedro River Basin. A summary of the soil characteristics is available through BLM (BLM, 1988). BLM has the responsibility of classifying the "wildlands" soils, complementing the functions of the Natural Resources Conservation Service. Within the Basin, several initiatives are dependent on completion of, or progress on, a wildlands survey and classification. The USGS's Desert Winds Project, described under desertification (above), needs a soils deposit map and a record of surface erosion. This information could be furnished, as the soils classifications are being accomplished.

g. Visitors Center. Since its creation in 1988, the San Pedro Riparian NCA has become a popular attraction and has experienced a tremendous increase in visitation. In turn, this increased interest has created a need, as well as an opportunity, to educate the public about the importance of riparian areas in the southwest and about the unique values of this riparian area in particular. The public in this case represents a broad spectrum of local, regional, national and international visitors and customers. To meet this need, BLM, working with the community, has developed a proposal to construct a visitor center on the NCA. In 1993, BLM received funding to prepare engineering plans and develop an architectural design for a visitor center.

The benefits of a visitor center extend well beyond its educational value. Studies completed in 1993 and 1994 projected a considerable economic and social benefit as well. The University of Arizona evaluated the economic benefit derived from visiting birders drawn to the Sierra Vista area and concluded that "birding" on the San Pedro Riparian National Conservation Area and The Nature Conservancy sites would, in themselves, pump roughly $3 million a year into the local economy (Crandall, et al, 1992). The State of Arizona conducted a survey and study to determine appropriate locations for visitor centers and sites in a state-wide context, based on meeting user needs without over-saturating an area. The San Pedro Riparian NCA Visitor Center was evaluated and found to be needed and necessary from the perspective of the statewide network of recreation sites as a whole.

The visitor center represents a critical step in elevating public awareness, which was identified as an issue and priority and discussed under the Education heading earlier in this report. Upon its completion, the visitor center will provide the public a better understanding of the biological aspects and ecological importance of riparian areas and of the hydrological relationships on which the NCA depends. They will be aware of the significance of the Upper San Pedro River Basin, and will recognize the economic and social benefits that can accrue to communities and regions that choose to protect such areas.

h. Weeds. Weeds are a nationwide concern that is receiving significant attention within DOI. The spread of noxious weeds is another form of desertification that Federal and State agencies must monitor closely. Weeds are a problem that affects numerous resources, programs, political and geographic boundaries, and special interest groups. The problem is delineated very well in the book Harmful Non-Indigenous Species in the United States, published by the former Office of Technology Assessment. The Animal, Plant, Health Inspection Service (APHIS), in the U.S. Department of Agriculture (DOA), has the lead on trying to maintain a weed-secure border, but DOI also must help support the effort, particularly in areas like the San Pedro Riparian NCA where the potential implications are so great. Any effort to address or contain the problem of weeds requires both an interagency and an international approach.

Sixteen federal agencies have signed an memorandum of understanding (MOU) forming the Federal Interagency Committee on the Management of Invasive and Exotic Weeds. This MOU paves the way for multi- agency cooperative efforts to eradicate or control the spread of weeds.

i. Wildfires. The Forest Service and BLM have recently issued a Federal Wildland Fire Management policy and program review. It can be found on the World Wide Web at http://www.fs.fed.us/land/wdfire.htm. Changes in fire suppression policies and the use of prescribed fire may have implications for future conditions in the Basin. One of the more important aspects of fire that is often given little consideration in fire policy is emergency fire rehabilitation, an aspect of great interest and concern to land management agencies such as the BLM and US Forest Service.

Departmental Manual, Wildland Fire Control and Management, Part 910, provides direction to DOI bureaus in administering fires. Wildland fires that threaten life, improvements or important natural resources are given priority over other bureau programs. Prescribed fires may be used to reach resource management objectives. BLM has developed a prescribed burn plan for each fuel type in the San Pedro Riparian NCA. This provided the flexibility to use a natural start for a prescribed burn. Prescribed fires are monitored to assure they remain within prescription (BLM, 1988).

4. RECOMMENDATIONS

In keeping with the objectives of this report and those of the Upper San Pedro River Basin Issue Team, which are to identify and compile shared natural resource data and information, and to develop recommendations based on that information to assist decision-making efforts, some recommendations are offered. Some that are more issue-specific have been presented within the appropriate sections of the report. Those that follow are broader, general recommendations which, if implemented, will establish a strong scientific framework, management foundation, and political environment needed to solve some of the resource management problems that exist.

◆ **The stakeholders involved on all sides of an issue will need to communicate, collaborate, and cooperate to achieve a successful long-term resolution of each issue.** Some models have already been developed for specific environmental components of the Basin, such as groundwater, and it may require only very modest efforts to integrate and expand existing efforts to create a more comprehensive environmental model that would meet the needs of resource managers. The missing pieces can be acquired easily, if the stakeholders combine their information and expertise.

◆ **The Department of the Interior should offer its expertise to non-federal agencies,** where it is clearly mutually beneficial. Geologic mapping needs to be validated and reconciled across the international boundary. Soil mapping needs to be enhanced, verified and corrected, on both sides of the border. These two steps will establish part of what is needed to support ground water modeling, ground water/surface water modeling, surface water quality studies and climate models. The next step would add climate information and model the surface water.

◆ **Geographic Information System (GIS) technology should be fully utilized** to ensure that all available data and information are compiled in interrelational databases, are widely accessible in consistent and flexible formats, and meet the needs of a variety of users and decision-makers. This will help to predict the extent and distribution of habitat for the plants and animals, and to identify where habitat could reasonably be improved, or where habitat cannot be improved under any reasonable circumstances. The development of such modeling capability would demonstrate our genuine desire to incorporate science and technology into everyday management decisions and into the process of developing effective alternatives.

◆ **The existing Water Resources Education Initiative should be encouraged to focus on the education needs and problems already identified for the Basin.** All program administrators and resource managers working in the Basin need to become partners in education. The scientific and management agencies have a responsibility to educate the public, both to achieve public support for improving the health of the land, and to facilitate informed conflict resolution.

E. BINATIONAL FORUMS, WORKSHOPS, AND SYMPOSIA

DOI United States-Mexico Border Field Coordinating Committee (FCC). As mentioned in the Introduction, the FCC provides a forum for DOI bureaus to improve coordination, cooperation and communication among themselves and it provides a focal point for those outside DOI interested in border issues. The Upper San Pedro River Basin has been identified as a priority for coordination and cooperation.

Border XXI. The mission of the United States-Mexico Border XXI Program is "to achieve a clean environment, protect public health and natural resources, and encourage sustainable development along the U.S.-Mexico border" (EPA, 1996). It is a binational effort by federal agencies to work cooperatively toward sustainable development through protection of human health and the environment and proper management of natural resources in both countries (EPA, 1996). The US Environmental Protection Agency has the lead responsibility. DOI has a co-lead responsibility with SEMARNAP for the Natural Resources Work Group. The Upper San Pedro River Basin has been recognized as an area of mutual interest and cooperation.

United States-Mexico Border States Conferences on Recreation, Parks and Wildlife. These conferences, which occur every 12-18 months, alternating between Mexico and the United States, provide an excellent forum to discuss issues of interest common to both countries related to recreation, parks and wildlife. A session on the Upper San Pedro River Basin was held at the last conference which was located in Hermosillo, Sonora, Mexico, in February 1997. The next conference will be in Tucson, Arizona, June 3-6, 1998.

Hispanic Association of Colleges and Universities (HACU). The HACU is committed to the preservation of the Americas' diverse cultural heritage and enhancement of the environment and natural resources. Their conferences, which are held periodically, address numerous cultural and environmental issues. These conferences provide another excellent opportunity to communicate actions being taken or needed on the numerous binational issues in the Upper San Pedro River Basin.

F. MEXICO PROJECTS

There are numerous opportunities for collaboration on cross-border research. Mexico has many ongoing projects in or adjacent to the Upper San Pedro River Basin. Some, if not all, of the following projects should be considered for binational participation:

1. Vegetation studies in Cañon de Evans en Sierra Los Ajos.
2. Vegetation studies in Cañon de Evans and lower Los Ajos Creek in Sierra Los Ajos.
3. Effects of fire on pine-oak forests in the Sierra Los Ajos.
4. Mexican spotted owl survey in Sierra Mariquita-Elenita and Los Ajos mountain ranges.
5. Rediscovery of black-tailed prairie dog in San Pedro River Basin in Mexico.

6. Fish studies in the Upper San Pedro River Basin in Mexico.
7. One breeding bird survey route in Upper San Pedro River Basin in Mexico.
8. Wildlife inventory in Sierra Mariquita Mountain range.
9. Imperial woodpecker survey and partial bird inventory at Sierra Los Ajos and north adjacent valley.
10. Some forest surveys in the mountain ranges surrounding Upper San Pedro River Basin in Mexico.
11. Water quality studies in the Upper San Pedro River Basin near the city of Cananea.
12. Wolf surveys in Sonora,
13. Wild turkey surveys in Sierra Los Ajos.
14. Flora of Sierra Los Ajos, New plants records.

During a meeting of the Upper San Pedro River Basin Issue Team on August 29, 1995, a group of individuals representing both countries developed the following list of potential cross-border projects. They are listed in no particular order and no priorities were assigned.

1. Establish monitoring wells in Mexico along the San Pedro River.
2. Cross-border habitat monitoring.
3. Develop a written agreement that provides for the exchange of spatial data between Centro Ecológico de Sonora and the Department of the Interior. Establish comparable GIS files, with metadata and themes deemed necessary by the Issue Team. A working group should go through each theme layer to make sure it is compatible.
4. Hands-on projects, such as building gabions to reduce runoff velocity, catch silt and stabilize small tributaries with headcutting problems.
5. Surface water monitoring (est. cost $5-10,000 each)
6. Make a comprehensive survey of native fish stock in Mexico; desert pupfish, dace, etc. (est. cost $10-15,000).
7. More complete inventory of plants.
8. Comprehensive inventory of riparian communities.
9. Locate and make available "grey literature."
10. Facilitate cross-border logistics and procedures, including the transport of equipment.
11. Bats--share data, monitor and identify.
12. Obtain BOR fish monitoring data.
13. Educate local people; including talking directly with them and using local radio and television.
14. Long-term health of riparian system, e.g., monitoring trends. What is the proper condition in the U.S. and Mexico?
15. Long-term economic/social forecasts and impacts on system.
16. Get better understanding of groundwater usage in Mexico.
17. Develop projects with local people involvement.
18. Work with individual landowners/groups that have an interest in getting help.

Success will help spread the good word.

These two lists of potential projects illustrate the tremendous range of opportunities that exist for binational cooperation in the Basin. Recent and current collaborative efforts have centered around the Upper San Pedro River Binational Education Program, which is described in Section V.A. of this report.

G. MECHANISMS FOR STAKEHOLDER INPUT

Although the BLM has direct responsibility to protect and manage the San Pedro Riparian National Conservation Area and its riparian resources, overall management of the myriad of resources in the Basin is fragmented. No single land manager can fulfill its responsibilities without support from the community and other stakeholders. Private utilities, the business community, local and state governments in the U.S., as well as in Mexico, and private citizens and interest groups have a broad range of interests and responsibilities that affect the ecosystem of this Basin and the way it is managed.

The resources of the Basin can be managed effectively only if the stakeholders support the management decisions. This requires their collective input and full participation in the process. It also requires that stakeholders develop a basic scientific understanding of the natural environment and the ecological, and hydrological processes that sustain the ecosystem.

Stakeholders also need to be aware of the institutional and legal considerations that may constrain management options. The limitations imposed by legal, staffing or budget constraints may be overlooked by some. The level of mutual understanding required in a truly collaborative process will not occur until the perspectives of all stakeholders are heard and valued, and their knowledge, skills, and abilities are incorporated into the management process. To this end it is recommended that a mechanism be developed to identify each and every stakeholder, their interests, responsibilities, concerns and abilities.

. It is suggested that a user-friendly database be established that is accessible, easy to use, and geared to all stakeholders working in the Basin. The information could be organized by resource information and stakeholder information. See Appendix G for an example.

V. RELATIONSHIP OF THIS EFFORT WITH OTHER EFFORTS

A. UPPER SAN PEDRO RIVER BASIN BINATIONAL EDUCATION PROGRAM

Human, floral and faunal communities in the Upper San Pedro River Basin coexist in a complex interdependent relationship. They rely on the same limited water supply and numerous interconnected resources which, in turn, depend on the river and its continued existence. These relationships do not recognize administrative boundaries or political borders. Thus, maintaining the health of the Basin and its associated resources is a goal that should be shared by all stakeholders. Understandably, it has become a concern of mutual interest to both the United States and Mexico. With this shared objective as a foundation, the United States and Mexico have organized a Collaborative Ecosystem Program Team to define issues and to develop an environmental education/training package for the Upper San Pedro River Basin. The Team is composed of resource managers, technicians, scientists, and academia. The Team's education effort focuses primarily on the exchange of information between the two countries. The ultimate objective of the Team is to achieve "binational sustainable resource management" of the Upper San Pedro River Basin.

The educational/training package is designed to bring focus to the issues affecting the Basin, to share technical knowledge that may have a bearing on those issues, and to disseminate current scientific and cultural information to those who are involved with sustaining and enhancing the long-term health of the Basin. The package also serves as a useful tool in future efforts directed at educating the general public. The training package addresses natural resource relationships, cultural resource values (archeological and historical), and socio-economic factors. Each education/training phase is expected to provide information that can be used to identify best management practices on the ground, and thereby move us one more step toward the survival of the Upper San Pedro River and the diverse resources of the Basin.

The first educational/training effort took place in September 1996. It involved about 35 people from the United States and Mexico, including representatives from the BLM, National Park Service, US Forest Service, US Army at Ft. Huachuca, USDA Agricultural Research Service, Arizona Game and Fish Department, Cochise County Extension Service, Sonoran Institute, Rincon Institute, Department of Ecology for the State of Sonora, CIDESON, Universities of Arizona and Sonora, and Cananea Mining Company. Commitments were made to form working groups for ranchers, wildlife management, beaver reintroduction, and international cultural resources. Development of a resource directory and a concept paper on a binational watershed conference were proposed.

B. SEMI-ARID LAND-SURFACE-ATMOSPHERE (SALSA)

The Semi-Arid Land-Surface-Atmosphere Program (SALSA) is an interdisciplinary, long-term monitoring and modeling effort that seeks to evaluate the consequences of natural and human induced change on the water balance and ecological diversity of semiarid basins at event, seasonal, interannual, and decadal time scales.

Though its focus is on the Basin, the findings that come from the SALSA program will

foster understanding of the ecological, hydrological, and meteorological processes that operate in many semiarid regions of the world. The program utilizes in-situ and remote sensing observations to study heat, water vapor, and $C0_2$ exchange between the land and atmosphere, surface water-groundwater interactions, biodiversity, and habitat change. Through these activities, SALSA intends to establish the Basin as the North American semiarid validation site for process-based models and products derived from remote sensing.

Many resource conflicts and management issues are found in the Basin, and have been described in an earlier section. With our present state of knowledge, we cannot address most of them effectively. That will require more data, a more complete understanding of the larger context in which the issues developed, and knowledge of the ecosystem dynamics and resource interrelationships. The most urgent information requirements are those related to surface-groundwater dynamics. Such information is critical for us to evaluate how activities like the rapid urbanization of the United States and the copper mining operation at the headwaters of the San Pedro River may be affecting the Basin's ground and surface water quality/quantity; and, further, what kind of threat they may pose for the San Pedro Riparian NCA. SALSA will be able to provide much of this information, or at least the raw data from which the information can be derived.

The underlying premise of the SALSA program is the need for an integrated research and data collection effort that cuts across disciplines, administrative and political jurisdictions, and parochial interests, and helps us understand Basin problems and issues on a basin-wide scale.

The SALSA program builds upon a large foundation of data collection efforts already underway in the Basin, supported by significant resources from seven federal, two state and two local agencies within the United States. These data collection efforts have been established to address critical water issues as designated by the San Pedro Technical Review Committee.

Approximately $500,000 is invested annually in the collection of water related data within the Basin. In addition, the USDA Agricultural Research Service maintains a collection of intensive, long term hydrologic data, spanning over 30 years, at the Walnut Gulch Experimental Watershed, a sub-basin of the Basin.

Other factors relevant to the SALSA program include NASA's selection of the Basin as an arid validation site for its Earth Observing Systems (EOS) ASTER instrument team, and its selection as the primary focus site for the EOS interdisciplinary science hydrology team at the University of Arizona and CESBIO, France. Two Sonoran state agencies have been involved in research in the Basin: Centro Ecologico de Sonora and CIDESON. The French organization, ORSTOM, has committed five scientists to work in the Mexican portion of the Basin for three years. In addition, six proposals have been funded for research and for acquisition of remotely sensed data in the Basin. This includes ERS-2, SPOT4, ADEOS and a mesoscale meteorological modeling initiative. Finally, Walnut Gulch/San Pedro has been selected as a Global Land Cover Test Site and is targeted for PRIRODA data acquisition from a Russian satellite.

The success of the SALSA program involves addressing the key research questions in the Basin, which will lead to a more complete understanding of Basin's energy balance and water resources. The goal of SALSA is to establish a credible research program that will not only produce viable scientific insight, but will also contribute answers helpful to resolving natural resource questions beyond the boundaries of the Basin, those questions relevant to society as a

whole. To highlight this important aspect of the program, the major societal, land and water-use issues are used to frame the important, integrative, scientific goals for the program. The major societal issues, along with some of the associated research studies, can be classified as follows:

Societal Issues: 1) Water resources allocation - development and improvement of relevant ground and surface water monitoring and models. The research goals include remote measurements of precipitation, soil-plant-atmosphere interactions, surface water and groundwater and evapotranspiration interactions, in situ and remote flux measurements, and mountain front recharge.

2) Use of remote sensing technology to evaluate ecological diversity and predict long-term landscape and habitat changes. The research goal is to develop the capability to utilize land surface characterization as a means to assess changes in the Basin's landscape, ecological diversity and health by monitoring viability of plant species and functioning ecosystems, and by conducting regional ecological assessments.

3) Climate change and desertification. The research goals include improved scientific understanding of how the Basin's hydrology and ecology interact with the regional climate. Information needs encompass land cover degradation and influences on local climate, scale issues and derivation of effective surface parameters, remote sensing of surface fluxes over heterogeneous terrain, and utilization of remotely sensed data in mesoscale meteorological models.

SALSA is a multinational effort, composed of scientists and land managers from a host of United States and Mexican federal and state agencies, and numerous universities. A number of institutions from Europe are also involved.

C. UPPER SAN PEDRO TECHNICAL REVIEW COMMITTEE

The Upper San Pedro Technical Review Committee (TRC) consists of hydrologists, scientists, engineers and decision-makers appointed by the Board of Supervisors of Cochise County to provide advice and guidance to the County, and to foster coordination of efforts related to the water resource.

The TRC has designed a number of data collection programs that are currently underway in the Sierra Vista sub-watershed. Data collection efforts are supported by seven Federal, two State, and two local government agencies; the University of Arizona; private consultants for the city of Sierra Vista; water companies; and several members from the public-at-large. The committee also provides peer-review, consultation on design, and coordination for the numerous studies now underway in the Basin.

Further, the TRC has recommended and undertaken a number of scientific investigations in the Basin, including, but not limited to: mainstream and tributary gages, well transects, groundwater models, gravimetrics, geochemical tracing, evapotranspiration measurements, aquifer recharge, precipitation monitoring, well logging, and riparian vegetation mapping.

The group is a forum for exchange and dissemination of water resource information, and

can play an important role in long-term public education.

D. GILA RIVER ADJUDICATION

The San Pedro River valley is a headwater basin of the Gila River. The General Adjudication of the Gila River System is a judicial proceeding to determine the water rights of thousands of users.

Adjudication is conducted in the State Superior Court of the county having the greatest number of potential claimants. The case is central to the future of water policy in the Basin. As mentioned previously, the process of adjudicating water rights within the San Pedro River watershed began on April 3, 1978, when the American Smelting and Refining Company (ASARCO) petitioned the Arizona State Land Department (SLD) for a determination on conflicting rights (from the Arizona Department of Water Rights - Hydrographic Survey Report, November 20, 1991). It has been called the largest court case in the state.

Water users in the Basin have been legally joined and are asserting their claims to water in these large judicial determinations of user rights. The adjudication is expected to finalize the water rights of cities, towns, farmers, ranchers, individual domestic users, state and federal government agencies, and Indian tribes.

Presently, however, a stay in the proceedings has been granted, in response to a challenge by several Native American tribes on a variety of constitutional issues, including diminimus rule amendments and comprehensive requirements of the McCarren Amendment.

A serious complication in the adjudication process arises from the fact that Arizona water law does not recognize the hydrologic connection between groundwater and surface water. Also, riparian vegetation is not legally recognized as a beneficial use for surface water. Arizona water law now recognizes in-situ water rights.

E. INTERNATIONAL BOUNDARY AND WATER COMMISSION

The International Boundary Commission was created by the Convention of March 1, 1889. The Water Treaty of February 3, 1994, for "Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande," changed the Commission's name to International Boundary and Water Commission (IBWC) and elevated it to the status of an international body.

The mission of IBWC is to exercise the rights and obligations of the United States and Mexico, as established by numerous boundary and water treaties and agreements, in a way that benefits the people on both sides of the border, socially and economically, and improves relations between the two countries.

The rights and obligations provided for in the treaties and agreements deal with: regulation and conservation of the waters of the Rio Grande and distribution of Rio Grande and Colorado River waters between the two countries; regulation of the Colorado River waters allocated to Mexico; protection of lands along the rivers from floods; solution of border sanitation and other border water quality problems; preservation of the Rio Grande and Colorado River as the international boundary, and demarcation of the land boundary.

Therefore, by virtue of its role in implementing these treaties and agreements, the IBWC becomes involved in all actions that may affect water availability, border sanitation, or water quality within the Upper San Pedro River Basin. IBWC also is interested in any water-related issues that may affect relations between the U.S. and Mexico.

F. BORDER ENVIRONMENT COOPERATION COMMISSION (BECC) AND NADBANK

The Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADBank) were created in November 1993, in connection with the North American Free Trade Agreement (NAFTA). The BECC and NADBank are bi-national institutions established to promote cooperation in achieving controlled development along the border that can be sustained without risks to the well-being of present and future generations. This is to be accomplished by focusing greater attention on protection, enhancement and, in some cases, preservation of the environment along the United States-Mexico border. The BECC gives U.S.-Mexico border communities a much greater role in determining their needs and identifying ways to meet them, and incorporates a mix of federal, state, local and private sector funding into solving them. The NADBank is one source of funding.

BECC works with states, local communities, other public entities and private investors to develop effective solutions to environmental problems in the border region. BECC may:

1) assist with the planning, design, construction management, operations and maintenance phases of environmental infrastructure projects;
2) assess the technical and financial feasibility of projects;
3) evaluate social, environmental, and economic impacts of projects;
4) assist with public and private financing for projects;
5) provide technical assistance to applicants in development of proposals, project feasibility planning, engineering design, and environmental assessments;
6) assist with the development of a comprehensive public outreach and participation plan, and
7) certify projects for financing by the NADBank or other sources.

The legal and financial structure of the NADBank is similar to that of multilateral development banks, such as the World Bank. However, the NADBank is unique in that it can operate in the United States and Mexico and can finance both public and private projects. However, it is limited in that it can only provide financing to environmental infrastructure projects certified by BECC.

NADBank performs it own analysis of each project. It also assists communities in designing financing mechanisms that are most appropriate and efficient for the individual community. It promotes innovative, indigenous, grassroots approaches to infrastructure financing. The NADBank supports sustainable development by helping to provide sustainable environmental infrastructure.

The NADBank is governed by a Board of Directors consisting of the US Secretary of

Treasury, US Secretary of State, Administrator of the US Environmental Protection Agency, Mexico's Secretary of Treasury, Mexico's Secretary of Social Development, and Mexico's Secretary of Commerce and Industry.

Projects located within 62 miles (100 kilometers) on either side of the U.S.-Mexico border, or that remedy a transboundary or health issue, may be considered for certification by BECC. Therefore, such projects within the entire Upper San Pedro River Basin will require certification by BECC.

To date, only one such project has been proposed that is located within the Basin. It is a request for an additional water supply and improvement of an existing waste water treatment facility at Naco, Sonora, Mexico. The project includes drilling, completing and connecting a new well in order to establish adequate water service. It also includes expanding and improving the existing wastewater ponds to provide adequate wastewater treatment and to support a recycling program using the treated wastewater.

The impacts of projects such as this, and of future projects brought before BECC for certification, whether such impacts are positive or negative, need to be communicated to resource managers and other interested parties for their review and input, and for their consideration in future resource management actions.

G. NORTH AMERICAN COMMISSION FOR ENVIRONMENTAL COOPERATION (CEC) SAN PEDRO RIPARIAN NATIONAL CONSERVATION AREA STUDY

On November 14, 1996, Earthlaw, on behalf of The Southwest Center for Biological Diversity and Dr. Robin Silver, filed a submission pursuant to Article 14 of the North American Agreement on Environmental Cooperation (NAAEC) seeking a finding that the United States was failing to effectively enforce the National Environmental Policy Act, with respect to the United States Army's operation of Fort Huachuca, Arizona (McKnight and Deihl, 1996).

Subsequently, the Secretariat for the CEC determined that the submission did not warrant the development of a factual record. However, in May 1997, the CEC decided to initiate an independent study and report of the water problems within the Basin under Article 13 of the NAAEC. The CEC has established a binational interdisciplinary team of experts to do the study. The study will provide an evaluation of the competing forces for water in the area, taking into account the importance of the San Pedro Riparian National Conservation Area for North America as a whole. Public input will be sought. The report also is to assess how the Basin can ensure sustainable use of water (Silva, 1997).

H. SAN PEDRO RIVER - A LANDSCAPE APPROACH TO COMMUNITY-BASED ENVIRONMENTAL PROTECTION

As mentioned previously, the US Environmental Protection Agency, National Exposure Research Laboratory, Las Vegas, Nevada, is conducting a project with a landscape approach to community-based environmental protection using the San Pedro River as a case study. The study focuses "on the influence of land cover composition, connectivity, patch size, and patch

abundance to evaluate ecosystem resilience and wildlife habitat suitability" (Kepner, 1995).

According to Kepner (1995), this study uses a multi-scale monitoring and assessment approach that can address a wide range of environmental issues, particularly those related to biodiversity. Landscape patterns and composition at multiple spatial and temporal scales can be evaluated. This project, which is a part of the SALSA Program, will evaluate changes in habitat suitability for selected species at multiple landscape scales. The status, changes and trend in wildlife habitat suitability over a twenty-year period will be determined using Landsat-MSS remote sensing imagery. The research will provide a process to identify ecosystems or specific biotic components potentially at risk of exposure to human-induced and natural environmental stressors (Kepner, 1995) within the Upper San Pedro River Basin, both in the United States and Mexico. Sub-basin components, such as grazing allotments and game units, also may be assessed (Kepner, 1996).

I. EFFECTS OF CLIMATE CHANGE ON THE SAN PEDRO RIVER WATERSHED

BLM, FWS, EPA, the University of Arizona, Arizona State University, US Forest Service, USDA Agricultural Research Service, and the Arizona Nature Conservancy are actively involved in research and studies regarding changes in the flora, fauna, hydrologic regimes, climate, and human land use practices in the Basin. These efforts are intended to gain a better understanding of past environmental conditions, changes in these conditions over time, and the cause and effect relationship between changes in land use and climate and the flora, fauna, hydrologic conditions and other environmental factors in the Basin.

BLM, the US Forest Service, and the University of Arizona have completed several land use histories and an ethnoecology study on portions of the Basin or in nearby areas. These studies have examined how various cultural groups have utilized this area and how these uses affected the plants, animals, hydrology and other environmental features of the area. Results of these studies have provided a better understanding of pre-settlement environmental conditions, changes in conditions over time and insights into the effects of livestock grazing, mining, surface water diversions, the use of wood as a primary fuel and many other human activities on the environment.

The University of Arizona, BLM, Cochise County, Gila River Indian Community, BIA and many other agencies have cooperated in the development and testing of computer generated hydrologic models of the Basin. These groups have worked together to assure that the models incorporate the best information available and will provide a useful tool for testing various water management scenarios. These models will be utilized in the testing of basin-wide management activities designed to assess the affects of groundwater use on the Basin's hydrologic system and the San Pedro River riparian ecosystem.

Arizona State University, in collaboration with the Arizona Nature Conservancy, has examined the relationship between surface water hydrologic regimes including floods of various magnitudes and successful regeneration of the native cottonwood willow plant community. Results of these studies have provided a better understanding of the hydrologic requirements necessary for successful regeneration of this community.

In 1991, BLM and the University of Arizona engaged in a five-year climate change

research project that focused on the United States portion of the Basin. The project was transferred to the National Biological Survey after three years of research were completed. The National Biological Survey continued to support this project through 1997. This project involves contemporary ecosystem studies, climate reconstruction studies, and ecological site and remote sensing inventories. The intent of the project was to further the understanding of the past and present relationships that exist between climate conditions, ecological communities and processes, hydrologic regimes and human land uses in the Basin. The ultimate objective of this project is the creation of a computer model capable of predicting changes in ecological communities and hydrologic regimes under various climate change scenarios.

The major objectives of the contemporary ecosystem study are to investigate the response of species and communities to changes in climatic parameters and to characterize the relationships between driving climatic parameters and the distribution of species and communities along operative parameter gradients that exist in the Basin. Progress in these studies have identified indicator species, the climatic parameters likely to affect their distribution, current distribution of these species and, in some cases, their past distributions. Techniques utilized in this investigation include stable isotope and opal phytolith analysis for indications of past change in vegetation species distribution as well as low level aerial videography to identify current species distribution.

Phytolith and carbon isotope data collection is complete and being analyzed. Initial results of the work indicate an increase in abundance and distribution of shrubs into grassland areas over the past 2700 to 3000 years. The isotope study shows the interface between oak woodland and grassland vegetation types to be moving down the elevation gradient, resulting in increasing area of oak-woodlands. (McClaran and Brady, 1994; McClaran and McPherson, 1995)

The objective of the climate reconstruction studies is to develop a detailed chronology of climate change in the Basin focusing on the last 1,000 years. Identification of important climate parameter gradients, their spatial and temporal variability as well as their major fluctuations in the past 1,000 years are investigated. To accomplish these objectives, historic climate data files were collected and analyzed, fossilized packrat middens have been collected and analyzed and tree ring samples have been collected and analyzed from the surrounding mountains.

Many of the previous studies of packrat middens focused on major climatic changes over longer periods of time since the last glacial period (about 11,000 years ago). This study attempted to evaluate minor shifts in climate in the Basin over the past 2,300 years (Van Devender, et. al., 1994). Initial packrat middens analysis indicates relatively few changes in species composition among shrubs and trees in the past 1,000 to 1,300 years. A decline in the occurrence of succulents that depend on summer moisture for recruitment suggests that on some of the sites summer moisture has become less dependable. There is evidence that changes in temperature and moisture are a more likely cause of more limited distribution of some grasses and shrubs than grazing impacts. However, some evidence of grazing impacts was also present. At all of the sites, modern vegetation is more xeric than at any earlier time in the period analyzed in this study. Results of the packrat middens and stable carbon isotope work are consistent with recent pollen analysis by Owen Davis at the University of Arizona. Declines in extent of cienegas and grasslands may be correlated with reduced fire frequency under human management of the past 100 years (Davis, 1994).

The objectives of the soils, ecological sites, and remote sensing inventory are to gather

and utilize information related to the temporal and spatial distribution of flora and fauna in the Basin to assist in reaching research objectives. Information from studies such as EPA's EMAP project and FWS's GAP project as well as the Arizona Game and Fish Department's state-wide riparian inventory and mapping project as well as other projects are expected to provide data and information pertinent to our needs. The final effort will be to create a computer model that will integrate this information into a predictive tool to be utilized in the prediction of ecosystem response to expected climate change scenarios.

Results from this research effort are expected to be used in developing management actions to address issues related to maintenance of species diversity, protection of elevational and latitudinal migration corridors, identification of microclimate refuges, prevention of exotic species invasions, identification of biological early warning indicators of climate change, mitigation of the effects of existing and future land uses, and the management of biological communities that are under climatic stress.

J. SHARED WATER RESOURCES ISSUE TEAM

The Shared Water Resources Issue Team of the Department of the Interior United States-Mexico Border Field Coordinating Committee, has prepared a map of the surface-water drainage basins shared between the United States and Mexico. This information is available as a Fact Sheet and also on the World Wide Web at the Field Coordinating Committee's Home Page at <http://www.doi.gov/fcc/english/water_fs-1.html>.

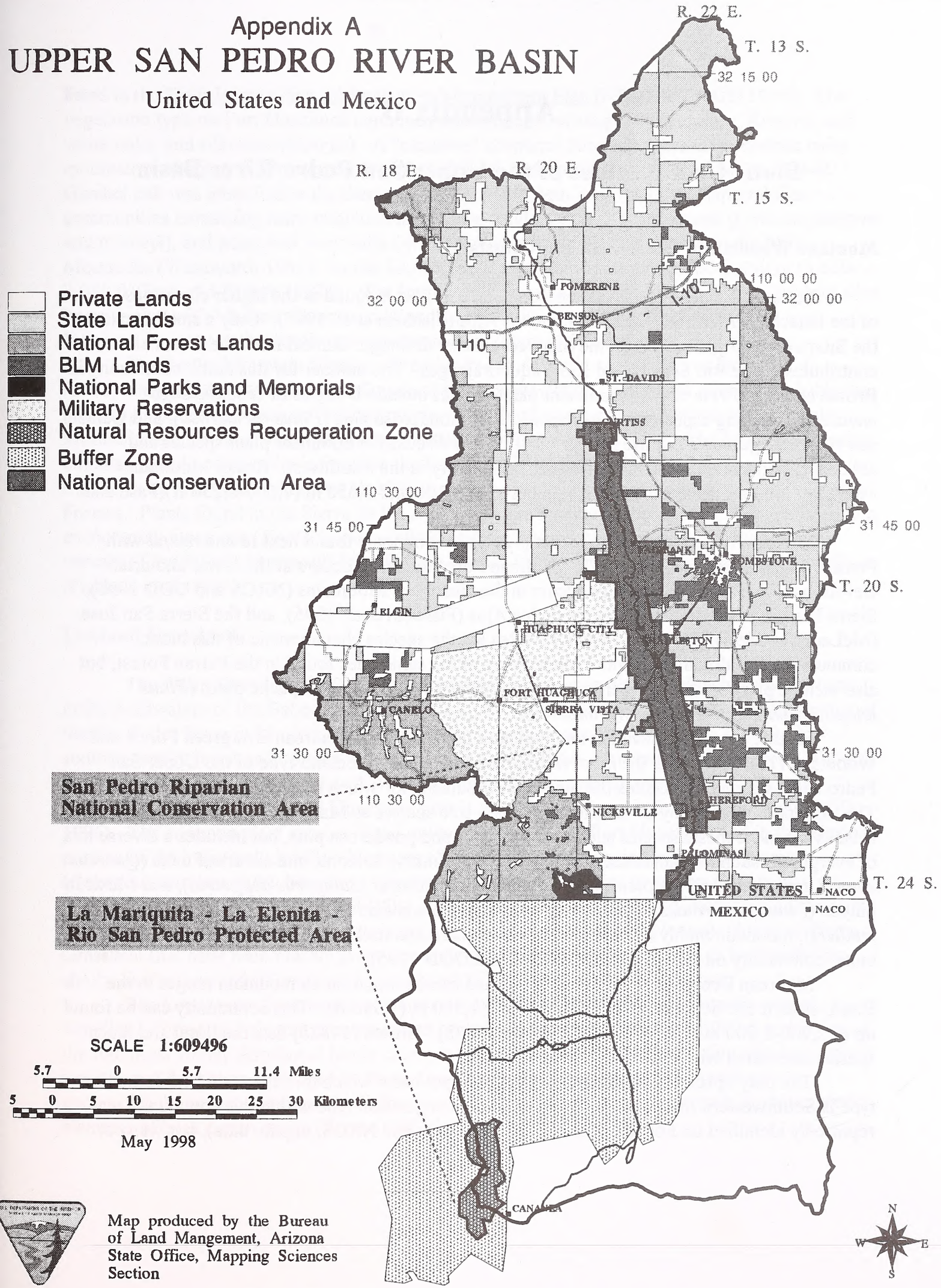
The 2000 miles of shared border are divided into eight subareas that have similar hydrologic and physiographic features. The basic hydrologic and geologic information, data deficiencies, major issues, and potential directions that future efforts should take are being defined for each subarea. A Fact Sheet addressing the water-resources issues in the Mexican Highlands subarea, which includes the Upper San Pedro River Basin, is available.

VI. APPENDICES

Appendix A

UPPER SAN PEDRO RIVER BASIN

United States and Mexico



Map produced by the Bureau of Land Mangement, Arizona State Office, Mapping Sciences Section

Appendix B

Biotic Communities of the Upper San Pedro River Basin

Montane Woodlands, Chaparral, and Grassland

Petran (Rocky Mountain) Montane Conifer Forest is found at the higher elevations of the Huachuca Mountains and Sierra de los Ajos (Fishbein et al. 1995). Only a small portion of the Sierra de los Ajos are within the San Pedro River drainage. Runoff from the Sierra also contributes to the Rio Sonora and Rio Yaqui drainages. The number for this biotic community in Brown et al. (1979) is 122.3. Dominant plant species include Douglas fir (*Pseudotsuga menziesii*), quaking aspen (*Populus tremuloides*), ponderosa pine (*Pinus ponderosa*), and Gambel oak (*Quercus gambelii*). Pase and Brown (1982*a*) discuss the dominant plant species and associated animal and plant species of this community in the Southwest. Rocky Mountain Montane Conifer Forest is usually found between 2,300 and 2,650 m (7,600-8,750 ft)(Pase and Brown 1982*a*).

Madrean Montane Conifer Forest (122.6) is commonly found next to and mixed with Petran Montane Conifer Forest. The Madrean Forest typically occurs at the lower and drier elevations. This biotic community occurs in the Huachuca Mountains (NRCS and DOD 1996), Sierra Mariquita (SIUE 1994), Sierra de los Ajos (Fishbein et al. 1995), and the Sierra San Jose (McLaughlin 1995). Pase and Brown (1982*a*) list the species characteristic of this biotic community. The dominant plants include many of the same ones found in the Petran Forest, but also include plants of Madro-Tertiary origin such as Chihuahua and Apache pines (*Pinus leiophylla chihuahuana* and *engelmannii*).

Further along the elevation and moisture gradient is the Madrean Evergreen Forest and Woodland (123.3). This is the most widespread forest and woodland type of the Upper San Pedro River Basin and includes the pine-oak woodlands for which the sky islands are famous. This community has many of the same dominant tree species as Madrean Montane Conifer Forest. It lacks the more mesic species such as Douglas fir and ponderosa pine, but includes a diverse mix of evergreens such as Chihuahua and Apache pine; Emory, Arizona, and silverleaf oaks (*Quercus emoryi, arizonica,* and *hypoleucoides*), alligator-bark juniper (*Juniperus deppeana*), and Mexican pinyon (*Pinus cembroides*). Most of these species, in addition to Fendler buckbrush (*Ceanothus fendleri*), mountain muhly (*Muhlenbergia montanus*), and rock cress (*Arabis*), were found in this biotic community on Fort Huachuca (NRCS and DOD 1996).

Madrean Evergreen Forest and Woodland can be found on all mountain ranges in the Basin, since it can be found at elevations below 1,500 m (4,950 ft). This community can be found up to 2,200-2,300 m (7,260-7,320 ft)(Brown 1982*b*). Brown (1982*b*) lists the floral and faunal species associated with this community.

The only upland biotic community in the upper basin which is in the scrubland formation type is Southwestern Interior Chaparral (133.3). A vegetation type within this community was reportedly identified on Fort Huachuca (Fort Huachuca and NRCS, unpub. data), but was not

listed in the Draft Interim Natural Resources Management Plan (NRCS and DOD 1996). The vegetation type on Fort Huachuca contained manzanita (*Arctostaphylos*), Emory, Arizona, and white oaks, and silktassel (*Garrya*). A "montane" chaparral community which contained hairy mountain-mahogany (*Cercocarpus brevifolius*), bush rockspirea (*Holodiscus dumosus*), and Gambel oak was identified in the Sierra de los Ajos (Fishbein et al. 1995). Chaparral like communities containing hairy mountain mahogany, sandpaper and Toumey oak (*Quercus pungens* and *toumeyi*), and point-leaf manzanita (*Arctostaphylos pungens*) were found in the Mule Mountains (Wentworth 1982). In the Southwest, chaparral is limited to 1,700-2,450 m (5,650-8,085 ft)(Pase and Brown 1982*b*). The Interior Chaparral community is often found on drier sites intermingled with Madrean Evergreen Woodland. The biotic and abiotic characteristics of Interior Chaparral in the Southwest are described by Pase and Brown (1982*b*).

The Rocky Mountain Montane Grassland (142.4) biotic community of Brown et al. (1979) is called Montane Meadow Grassland by Brown (1982*c*). The latter name is probably the most appropriate one because this community or analogs may be found surrounded by Rocky Mountain, Sierran, and Madrean montane conifer forests (Brown 1982*c*). The Montane Meadow Grassland biotic community is found in the Huachuca Mountains (Deecken, pers. comm.) and in the Sierra de los Ajos (Fishbein et al. 1995) as small openings in the Petran and Madrean Conifer Forests. Plants found in the Sierra de los Ajos meadows include pine dropseed (*Blepharoneuron tricholepis*), junegrass (*Koeleria macrantha*), carrotleaf larkspur (*Delphinium tenuisectum*), vervain (*Glandularia bipinnatifida*), Mexican camion (*Silene laciniata*), and *Vigueria multiflora* (Fishbein et al. 1995).

Lowland Grasslands

The Plains Grassland (142.1) biotic community occurs next to the Huachuca Mountains, in the headwaters of the Babocomari River, Campini Mesa, Fort Huachuca, and the headwaters of the San Pedro River in Mexico. This community occurs mostly above 1,500 m (4,950 ft) in southeastern Arizona and northeastern Sonora (Brown 1982*d*). Precipitation is between 300-460 mm (11.8-18.1") with greater than 50% occurring in the summer (Brown 1982*d*). Average annual precipitation on the Fort Huachuca sites is from 400-500 mm (16-20")(NRCS and DOD 1996). The common plant species found in Plains Grassland at Fort Huachuca and in the Mexican portion of the basin included little bluestem (*Schyzachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), bluestems (*Andropogon* spp.), and plains lovegrass (*Eragrostis intermedia*)(SIUE 1994, NRCS and DOD 1996). Frequently encountered shrubs include yuccas (*Yucca* spp.), palmer agave (*Agave palmeri*), and mesquite (*Prosopis velutina*). Areas of Plains Grassland that have been heavily grazed or undergone other disturbance tend to be invaded by shrubs like snakeweed (*Gutierrizia*), rabbitbrush (*Chrysothamnus*), and *Mimosa*.

The Semidesert Grassland biotic community (143.1) occurs below Plains Grassland, woodland, forest, and chaparral communities and above desertscrub (Brown 1982*e*) and is one of the two most widely distributed biotic communities of the Basin. Semidesert Grassland occurs on warmer and drier sites compared to Plains Grassland. Because Semidesert Grassland is geographically positioned between Plains Grassland and Chihuahuan Desertscrub, it shares biotic elements of both communities (Brown 1982*e*).

Grassland communities are reduced from what they were historically (Hastings and Turner 1965, Davis 1986, Bahre 1991, EPA 1997). Coverage of grassland communities (Plains Grassland and Semidesert Grassland) in the Basin decreased by 35 percent between 1974 and 1987 (EPA 1997). Grasslands have been replaced by woodland and desert scrub communities. During 1974-1987 grassland communities also became increasingly fragmented. The number of grassland patches increased 61 percent while average grassland patch size decreased by 60 percent (EPA 1997). Replacement of grassland with scrub and woodland communities has been attributed to overgrazing, reduced fire frequency, climate change, changes in herbivore communities, and an increase in atmospheric CO_2 (see review in Archer 1994). Grassland communities have also been lost to urbanization and agriculture and degraded due to wild hay harvest and introduction of nonnative plants such as Lehmann lovegrass (*Eragrostis lehmanianna*) (Bahre 1995). Lehmann lovegrass, a warm-season perennial African bunchgrass common in the Basin, has a competitive edge over native grasses in areas grazed by cattle (Martin 1983, Anable et al. 1992, NRCS and DOD 1996). In the Southwest, livestock grazing is likely the most important proximate cause for observed reductions in grassland communities (Hastings and Turner 1965, York and Dick-Peddie 1969, Bahre and Bradbury 1978, Archer 1990, Bahre 1991, 1995).

Because of grassland degradation, much of the area classified as Semidesert Grassland looks and functions more like a desertscrub community because of the invasion by shrubs. In fact, some areas in the basin that were historically Semidesert Grassland are now Chihuahuan Desert (Hastings and Turner 1965). On first inspection in some areas, it can be difficult to find the bunchgrasses that are characteristic of this biotic community. Common grass species include big sacaton (*Sporobolus wrightii*), Lehmann lovegrass, sideoats and other gramas, tobosa (*Hilaria mutica*), threeawn (*Aristida*), and bush muhly (*Muhlenbergia porteri*). Typical undisturbed Semidesert Grassland communities contain a diverse shrub complex consisting of sotol (*Dasylirion*), yucca, agave (*Agave*), mesquite, and Mormon tea (*Ephedra*). Plants typical of the Chihuahuan Desert, such as mesquite and creosote (*Larrea tridentata*), have invaded Semidesert Grassland. These scrub disclimax areas continue to increase in extent (EPA 1997). Brown (1982*e*) summarizes the biotic and abiotic characteristics of this community in the Southwest.

Desertscrub

Chihuahuan Desertscrub (153.2) covers about the same area in the Basin as Semidesert Grassland. As discussed in the previous section, the amount of Chihuahuan Desertscrub has increased at the expense of Semidesert Grassland (York and Dick-Peddie 1969). The Chihuahuan Desert was first mapped and described by Forrest Shreve (1942, 1951). The Basin contains a disjunct outlier of the Chihuahuan Desert and is the westernmost extension of this warm temperate desert (Ohmart 1979). The western portions of the Chihuahuan Desert occur almost exclusively on limestone or other calcareous soils (Wentworth 1982, McLaughlin and Bowers 1990). Temperatures at or below freezing may be expected on more than 100 nights of the year. Frequency and duration of freezing temperatures are the main factor determining the boundary between the Sonoran and Chihuahuan Deserts. Most precipitation (~60%) in the Basin falls during the summer (Brown 1982*f*).

The Chihuahuan Desert is considered a shrub desert with common shrubs being creosote, tarbush (*Flourensia cernua*), and Chihuahua whitethorn (*Acacia neovernicosa*). These shrubs are common in the Upper San Pedro River Basin and each may be the dominant plant singly or in combination with the others. Mesquite is commonly encountered as are the sub-shrubs desert zinnia (*Zinnia acerosa*), snakeweed, four-wing saltbush (*Atriplex canescens*), and mariola (*Parthenium incanum*). Few grasses are present, but may include tobosa, big sacaton, and bush muhly. Further descriptions of the Chihuahuan Desertscrub biotic community can be found in Brown (1982*f*) and the work done by BLM on the San Pedro Riparian National Conservation Area (Duncan 1988; BLM 1989; BLM and AGFD 1993).

Riparian and Wetland Communities

Determining which wetland biotic communities occur in the Basin is difficult because they are often too small to plot on small scale maps or are lumped with the more ubiquitous wetland communities. If a wetland biotic community is mapped, it usually is the most dominant or important one present. The cottonwood-willow forest of the Interior Southwest Riparian Deciduous Forest and Woodland (223.2) biotic community is the wetland biotic community most frequently mapped. Known or probable wetland biotic communities are shown in Table 2. In addition these communities change often due to disturbance and succession (Minckley and Brown 1982). The different formation types and associated biotic communities are most often found intermingled with each other dependent on the timing of the last disturbance and site characteristics. Wetland biotic communities play a large role in the pivotal biotic diversity of the Basin, especially for the faunal component of the community (Carothers and Johnson 1975, Stamp and Ohmart 1979, Lowe 1989).

Table 2. Riparian and wetland biotic communities of the Neartic biogeographic realm[1] of the Upper San Pedro River Basin, United States and Mexico, and their relationship to other classification levels. Adapted from Brown et al. (1979) and Brown et al. (1995).

Level	Hierarchy												
Formation Type 10	Forest & Woodland (20)		Swamp-scrub (30)	Marsh-land (40)	Strand (50)	Submerg-ent Aquatic Vegetation (60)	Forest & Woodland (20)	Swamp-acrub (30)	Marahland (40)	Strand (50)	Submergent Aquatic Vegetation (60)	Marsh-land (40)	Strand (50)	Submerg-ent Aquatic Vegetat-ion (60)
Climatic Zone 1	Cold Temperate (2)						Warm Temperate (3)						
Biogeograph-ic Province	Rocky Mountain	Madrean	Rocky Mountain				Interior Southwest		Chihuahuan			Madrean		
Biotic Commun-ity 0.1	Rocky Mountain Riparian Deciduous Forest (222.3)	Madrean Montane Riparian Forest (222.5)	Rocky Mountain Riparian Scrub (232.3)	Rocky Mount-ain Marsh-land (242.4)	Rocky Mount-ain Stream & Lake Strand (252.4)	Rocky Mountain Montane Submerg-ents (262.4)	Interior South-west Riparian Decidu-ous Forest & Woodland (223.2)	Interior Southwest Swamp & Riparian Scrub (233.2)	Chihua-huan Interior Marshland (243.3)	Chihua-huan Interior Strand (253.3)	Chihuahuan Inland Submerg-ents (263.3)	Madrean Marsh-land (243.5)	Madrean Stream & Lake Strand (253.5)	Madrean Inland Submerg-ents (263.5)

[1] Neotropical biotic communities (Sonoran) of each formation type may occur in the northern end of the basin. They do occur in the Lower San Pedro River Basin, and to the west and south.

Rocky Mountain Riparian Deciduous Forest (222.3) occurs in the higher, cooler, and more mesic canyons of the Huachuca Mountains (Szaro 1989; Fort Huachuca and NRCS, unpub. data) and Sierra de los Ajos (Fishbein et al. 1995), and possibly the Sierra Mariquita. Dominant plant species found include bigtooth maple (*Acer grandidentatum*), white fir (*Abies concolor*), and Arizona walnut (*Juglans major*).

The NRCS and DOD (1996) identified the Madrean Montane Riparian Forest Biome as occurring on Fort Huachuca. This biotic community is not identified in Brown et al. (1979). Minckley and Brown (1982) discuss "Montane Riparian Wetlands". It appears that Minckley and Brown's (1982) montane wetlands included Rocky Mountain, Madrean, and Sierra Nevadan biotic communities. The Madrean Montane Riparian Forest biotic community on Fort Huachuca probably included Rocky Mountain Riparian Deciduous Forest as species found there include bigtooth maple and Douglas fir (NRCS and DOD 1996). Other species identified include Arizona sycamore, Arizona walnut, Fremont cottonwood, and Arizona ash. This biotic community occurs on the Fort at 1700-2000 m (5600-6600')(NRCS and DOD 1996).

The most important wetland biotic community, due to its characteristics and relatively widespread distribution in the Basin, is Interior Southwest Riparian Deciduous Forest and Woodland (223.2). The most common vegetation type of this community is cottonwood-willow, usually Fremont cottonwood and Gooding willow. The higher and cooler sites within the Interior Southwest biogeographic province are distinguished by trees such as Arizona sycamore (*olatanus wrightii*), velvet ash (*Fraxinus velutina*), Arizona walnut, and willows.

The cottonwood-willow type is the most common riparian vegetation type found along the upper San Pedro River (BLM and AGFD 1993). The San Pedro Riparian National Conservation Area Habitat Management Plan (BLM and AGFD 1993:4) shows mesquite vegetation associations or types as being the most widespread wetland vegetation type. However, much of the two types they identified, especially the mesquite-short tree association, should not be considered as wetland vegetation types. In the National List of Wetland Plants (Reed 1988), mesquite is classified as a "Facultative Upland" species. Facultative upland plants usually occur in non-wetlands (67-99%), but are occasionally found in wetlands (1-33%)(Reed 1988). Bosques or forests or large trees lining the San Pedro River are likely "riparian" though, due to periodic riverine flooding of the higher terraces where mesquite bosques occur, and the deep root systems of mesquites (Nilsen et al. 1983, Wendt et al. 1968). Stromberg et al. (1996) found that the mature mesquite forests on the San Pedro River occupied high floodplain terraces that were relatively far from the river in areas of deep groundwater.

A Sonoran Riparian deciduous Woodland Biome was identified on Fort Huachuca (NRCS and DOD 1996). The specific site was a mesquite bosque that occurred on floodplains and stream terraces. However, this biotic community is probably Interior Southwestern Riparian Deciduous Forest and Woodland and not Sonoran. Freezing temperatures are too frequent in the Basin for Sonoran Sub-tropical communities to occur (Sellers and Hill 1974, Brown et al. 1979). Sonoran wetland biotic communities are restricted to below 1,200 m (4,000') in elevation and are immediately adjacent to Sonoran Desert upland biotic communities.

Rocky Mountain Riparian Scrub (232.3) was documented on Fort Huachuca (Ft. Huachuca and NRCS, unpub. data). This biotic community is most likely found mixed with Rocky Mountain Riparian Deciduous Forest in the Huachuca Mountains and possibly in the

Sierras de los Ajos and Mariquita. Shrubs found in the Fort Huachuca vegetation type were red-osier dogwood (*Cornus stolonifera*) and arroyo willow (*S. lasiolepis*). This biotic community is probably very limited in both area and distribution in the Basin.

The Interior Southwest Swamp and Riparian Scrub biotic community (233.2) has been recorded on the San Pedro River (BLM 1989, BLM and AGFD 1993) and probably also occurs at the higher elevations. The common shrubs of this community include desert willow (*Chilopsis linearis*), threadleaf groundsel (*Senecio longilobus*), salt cedar (*Tamarix chinensis*) (Duncan 1988), seepwillow (*Baccharis salicifolia*), catclaw (*Acacia greggii*) (Minckley and Brown 1982), and burrobush (*Hymenoclea monogyra*)(BLM and AGFD 1993).

Of the three marshland biotic communities that may occur in the Basin, only Chihuahuan Interior Marshland (243.3) has been documented (Duncan 1988, BLM 1989, BLM and AGFD 1993). The other two biotic communities probably occur in the mountain ranges of the Basin as an understory or where taller vegetation cannot establish. The St. David Cienega on the San Pedro Riparian NCA is the best example of Chihuahuan Interior Marshland in the Basin. This community also occurs as small patches along the San Pedro River and was much more widespread historically (Hendrickson and Minckley 1984, Davis 1986). Common plants of Chihuahuan Interior Marshland are cattail (*Typha domingensis*), bulrush (*Scirpus*), sedges (*Carex*), rushes (*Juncus*), and spikerush (*Eleocharis*) (Minckley and Brown 1982).

Strand habitats occur in floodplains where scouring, flooding, or sediment deposition create harsh environments (Minckley and Brown 1982). These habitats tend to be highly transitory in nature and are distinguished by a sparse growth of vegetation. Strands are found on low terrace, overflow channel, and mid-terrace ecological sites.

Strand biotic communities (formation type 250) potentially occur in the Rocky Mountain, Madrean, and Chihuahuan biogeographic provinces (Brown et al. 1979). Minckley and Brown (1982:266) show an example of Chihuahuan Interior Strand (253.3) on the San Pedro River. When vegetation occurs on these coarse-soiled habitats, it is frequently seedlings of woody species, salt cedar, annuals, biennials, and short lived perennials (Minckley and Brown 1982). Rocky Mountain and Madrean Strand Communities probably occur within the mosaic of riparian and wetland habitats within those biogeographic provinces in the higher mountains.

The occurrence and position of submergent aquatic plant biotic communities is similar to Strand biotic communities. These biotic communities are restricted to areas of permanent water. The Chihuahuan Inland Submergent biotic community (263.3) certainly occurs along the San Pedro River. Common submergent aquatic plants include pondweed (*Potamageton*), milfoil (*Myriophyllum*), naiad (*Najas*), duckweed (*Lemna*), and watercress (*Rorippa*)(Minckley and Brown 1982, Hendrickson and Minckley 1984). The Rocky Mountain Montane Submergent (262.4) and Madrean Inland Submergent (263.3) biotic communities may occur interspersed with other wetland communities in the higher mountains of the basin.

Appendix C

Special Status Species and Communities

Table 3. Special Status Species known or suspected to occur in the Upper San Pedro River Basin.

Common name	Scientific name	Status[1]	Presence[2]
FISH			
Gila chub	*Gila intermedia*	C, AZ	extant
spikedace	*Meda fulgida*	T, AZ	extirpated
Colorado squawfish	*Ptychocheilus lucius*	E, AZ	extirpated
loach minnow	*Tiaroga cobitis*	E, AZ	extirpated
razorback sucker	*Xyrauchen texanus*	E, AZ	extirpated
desert pupfish	*Cyprinodon macularius macularius*	E, AZ	extirpated[3]
Gila topminnow	*Poeciliopsis o. occidentalis*	E, AZ	extirpated[3]
Amphibians			
Sonora tiger salamander	*Ambystoma tigrinum stebbinsi*	E, AZ	extant
barking frog	*Eleutherodactylus augusti*	AZ	extant
Chiricahua leopard frog	*Rana chiricahuensis*	C, AZ	extant
Ramsey Canyon leopard frog	*R. subaquavocalis*	AZ	extant

Snakes			
Arizona ridge-nosed rattlesnake	*Crotalus willardi*	AZ	extant
massasauga	*Sistrurus catenatus*	AZ	extant
Mexican garter snake	*Thamnophis eques*	AZ	extant
Birds			
snowy egret	*Egretta thula*	AZ	extant
Great egret	*Casmerodius albus*	AZ	extant
black-bellied whistling duck	*Dendrocygna autumnalis*	AZ	extant
osprey	*Pandion haliaetus*	AZ	extant
Mississippi kite	*Icterina mississippiensis*	AZ	possible
bald eagle	*Haliaetus leucocephalus*	T, AZ	extant
northern goshawk	*Accipiter gentilis*	AZ	extant
gray hawk	*Buteo nitens*	AZ	extant
ferruginous hawk	*B. regalis*	AZ	extant
black hawk	*B. anthracinus*	AZ	extant
caracara	*Caracara plancus*	AZ	extant
northern aplomado falcon	*Falco femporalis septentroalis*	E, AZ	extirpated[3]
peregrine falcon	*F. peregrinus*	E, AZ	extant
western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	AZ	extant
Mexican spotted owl	*Strix occidentalis lucida*	T, AZ	extant
Violet-crowned hummingbird	*Amazilia violiceps*	AZ	extant
elegant trogon	*Trogon elegans*	AZ	extant

belted kingfisher	*Ceryle alcyon*	AZ	extant
southwestern willow flycatcher	*Empidonax traillii extimus*	E, AZ	extant
buff-breasted flycatcher	*Empidonax fulvifrons*	AZ	extant
tropical kingbird	*Tyrannus melancholicus*	AZ	extant
thick-billed kingbird	*T. crassirostris*	AZ	extant
Mammals			
Arizona shrew	*Sorex arizonae*	AZ	extant
California leaf-nosed bat	*Macrotus californicus*	AZ	extant
Mexican long-tongued bat	*Choeronycteris mexicana*	AZ	extant
lesser long-nosed bat	*Leptonycteris yerbabuenae*	E, AZ	extant
western red bat	*Lasiurus blossevillii*	AZ	extant
southern yellow bat	*Lasiurus ega*	AZ	possible
Mexican gray wolf	*Canis lupus mexicanus*	E, AZ	possible
Jaguar	*Felis onca*	E, AZ	possible
Ocelot	*Felis pardalis*	E, AZ	extirpated (?)
Jaguarundi	*Felis yagouaroundi*	E	extirpated (?)
Plants			
Huachuca water umbel	*Lilaeopsis shaffneriana* var. *recurva*	E	extant
Canelo Hills ladies' tresses	*Spiranthes delitescens*	E	extant
Chiricahua dock	*Rumex orthoneurus*	C	extant
Lemmon fleabane	*Erigeron lemmonii*	C	extant

Huachuca groundsel	*Senecio huachucanus*	C	extant

[1] E = federally endangered
T = federally threatened
C = candidate for federal listing
AZ = Wildlife of Special Concern in Arizona (Draft)
[2] Extant = occurs at this time
Possible = may occur in the basin or occurs nearby
Extirpated = no longer occurs in the basin, but does occur elsewhere
[3] potentially suitable habitat occurs in the basin for reintroduction

SOUTHWESTERN WILLOW FLYCATCHER

The southwestern willow flycatcher is a small passerine bird (Order Passeriformes; Family Tyrannidae) measuring approximately 14.6 cm (5.75 inches) in length from the tip of the bill to the tip of the tail and weighing only 11 grams (0.4 ounces). It has a grayish-green back and wings, whitish throat, light gray-olive breast, and pale yellowish belly. Two white wingbars are visible (juveniles have buffy wingbars). The eye ring is faint or absent. The upper mandible is dark, the lower is light yellow grading to black at the tip. The subspecies was listed as endangered under the Federal Endangered Species Act on February 27, 1995 (Service 1995). Critical habitat was designated on July 22, 1997, including a reach of the upper San Pedro River from Hereford Bridge to the Interstate 10 bridge at Benson (Service 1997).

One of four currently-recognized willow flycatcher subspecies (Phillips 1948, Unitt 1987, Browning 1993), the southwestern willow flycatcher is a neotropical migratory species that breeds in the southwestern U.S. from approximately April 1 to September 1 and migrates to Mexico, Central America, and possibly northern South America during the non-breeding season (Phillips 1948, Stiles and Skutch 1989, Peterson 1990, Ridgely and Tudor 1994, Howell and Webb 1995). The historical range of the southwestern willow flycatcher included southern California, Arizona, New Mexico, western Texas, southwestern Colorado, southern Utah, extreme southern Nevada, and extreme northwestern Mexico (Sonora and Baja) (Unitt 1987).

The flycatcher is a riparian obligate, nesting along rivers, streams, and other wetlands where dense growths of willow, *Salix* sp., seepwillow, *Baccharis* sp., buttonbush, *Cephalanthus* sp., boxelder, *Acer negundo*, saltcedar or other plants are present, often with a scattered overstory of cottonwood and/or willow.

Unitt (1987) reviewed historical and contemporary records of *E.t. extimus* throughout its range, determining that it had "declined precipitously..." and that although the data reveal no trend in the past few years, the population is clearly much smaller now than 50 years ago, and no change in factors responsible for the decline seem likely. The current known population of southwestern willow flycatcher is estimated at 300-500 pairs. Breeding occurs at approximately 75 sites (Sogge et al. 1997). Declining numbers have been attributed to loss, modification, and fragmentation of habitat, and brood parasitism by the brown-headed cowbird (*Molothrus ater*) (Sogge et al. 1997).

In the Basin, flycatchers were found near Saint David in 1996, and in 1997, one flycatcher nest was found near Kingfisher (or Young-Block) ponds just south of Highway 90 in the San Pedro Riparian NCA. Two territorial males were also found in 1997 upstream, and one was downstream of Kingfisher ponds on the San Pedro Riparian NCA (T. McCarthy, AGFD, pers. comm. 1997). Surveys of potential habitats in the Basin are incomplete, but most or all potential habitat occurs along the San Pedro River. A larger population of southwestern willow flycatchers exists on the lower San Pedro River from Mammoth to the Gila River confluence.

As an endangered riparian-obligate species, the fate of the flycatcher in the Basin is tied to local water issues. A large number of hydrologic studies have been conducted since the mid 1980's in the Basin, primarily in support of an ongoing water rights adjudication process that involves the entire Gila Basin in Arizona. All studies of which we are aware that compared water use and recharge in the Basin have concluded that use exceeds recharge. One estimate of the annual deficit is approximately 11,200 acre feet (ASL 1994). Most studies agree that declining groundwater elevation, well-documented in the Sierra Vista-Fort Huachuca area and at Hereford-Palominas, will or already has affected river flows. The Sierra Vista-Fort Huachuca cone of depression may have also affected flows in the Babocomari River, a major tributary to the San Pedro River. Most studies conclude that groundwater pumping by agricultural and municipal users, and Fort Huachuca, will result in elimination of base flows in the upper San Pedro River if left unmitigated. A reduction or elimination of base flows would be followed by degradation of the riparian habitats of the San Pedro River (Stromberg et al. 1996), including the habitat of the flycatcher. If Federal actions, such as groundwater pumping at Fort Huachuca, section 404 permits issued by the US Army Corps of Engineers for development projects, or other Federal actions contribute to the groundwater deficit, these actions would be subject to the consultation requirements in section 7 of the Endangered Species Act. Through such consultations, FWS can make mandatory changes to proposed actions to protect endangered species such as the southwestern willow flycatcher and their critical habitat.

HUACHUCA WATER UMBEL

The Huachuca water umbel was listed as an endangered species on January 6, 1997. No critical habitat has been proposed or designated. The umbel is an herbaceous, semiaquatic

perennial plant with slender, erect leaves that grow from creeping rhizomes. The yellow/green or bright green leaves are generally 1.0-3.0 mm (0.04-0.12 inch) in diameter and often 2.5-5.0 cm (1.0-2.0 inches) tall, but can reach up to 20 cm (8 inches) tall under favorable conditions. Three to 10 very small flowers are borne on an umbel that is always shorter than the leaves. The fruits are globose, 1.5-2.0 mm (0.06-0.08 inch) in diameter, and usually slightly longer than wide (Affolter 1985).

Huachuca water umbel has been documented from 23 sites in Santa Cruz, Cochise, and Pima counties, Arizona, and in adjacent Sonora, Mexico, west of the continental divide (Saucedo 1990, Warren et al. 1989, Warren et al. 1991, Warren and Reichenbacher 1991, Service files). The plant has been extirpated from six of the 23 sites. The 17 extant sites occur in four major watersheds - San Pedro River, Santa Cruz River, Rio Yaqui, and Rio Sonora. All sites are between 1,060 and 2,000 meters (3,500 to 6,500 feet) elevation. Huachuca water umbel has an opportunistic strategy that ensures its survival in healthy riverine systems, cienegas, and springs. In upper watersheds that generally do not experience scouring floods, the umbel occurs in microsites where interspecific plant competition is low. In stream and river habitats, Huachuca water umbel can occur in backwaters, side channels, and nearby springs. After a flood, it can rapidly expand its population and occupy disturbed habitat until interspecific competition exceeds its tolerance. This response was recorded at Sonoita Creek in August 1988, when a scouring flood removed about 95 percent of the Huachuca water umbel population (Gori et al. 1990). One year later, the umbel had recolonized the stream and was again codominant with watercress, *Rorippa masturtium-aquaticum* (Warren et al. 1991). The expansion and contraction of Huachuca water umbel populations appears to depend on, a watershed that has an unaltered hydrograph, a healthy riparian community that stabilizes the channel, and the presence of refugia where the species can escape the effects of scouring floods. The types of microsites or refugia required by the umbel were generally lost from the main stems of the San Pedro and Santa Cruz rivers when channel entrenchment occurred in the late 1800's; however, umbel habitat and populations are recovering on the upper San Pedro River.

In the Basin, Huachuca water umbel occurs in several riparian canyons on the west slope of the Huachuca Mountains, at Fort Huachuca, in the Sierra de los Ajos, Ojo de Agua de Cananea, and in the San Pedro River. Decline of this endangered plant is attributable to habitat loss and degradation resulting from livestock overgrazing, water diversions, dredging, groundwater pumping, and introduction and spread of nonnative plants. This plant is also threatened by stochastic extirpation or extinction resulting from floods or drought; a threat that is exacerbated by small numbers and populations of this taxon.

The Huachuca water umbel was located on the San Pedro Riparian NCA in 1994. Mark Fredlake (BLM, Sierra Vista, AZ, pers. comm. 1996) and Dave Gori (The Nature Conservancy, Tucson, AZ, pers. comm. 1996) located 43 patches of Huachuca water umbel during 1995 and 1996. These patches occur in five disjunct areas from approximately 3.2 km (2.0 miles) downstream of Fairbank to approximately 1.6 km (1.0 mile) north of Hereford. The entire San Pedro Riparian NCA is considered potential habitat for the Huachuca water umbel. It is the largest contiguous potential habitat of the umbel, and as such is considered the most important site for recovery.

Like the southwestern willow flycatcher, the fate of the umbel is tied to resolution of local

water issues. If groundwater pumping continues to exceed recharge, base flows in the San Pedro River will eventually decline and the habitat of the Huachuca water umbel will be lost. Loss of this habitat would significantly affect the potential for recovering this species to a point where it no longer needed the protection afforded by Federal listing.

CHIRICAHUA LEOPARD FROG

The Chiricahua leopard frog was described in the scientific literature less than 20 years ago (Platz and Mecham 1979). Before that time, it was lumped with the broad-ranging northern leopard frog (*Rana pipiens*). This new species was distinguished from other members of the *Rana pipiens* complex by a combination of characters, including a distinctive pattern on the rear of the thigh consisting of small cream-colored tubercles on a dark background, dorsolateral folds that were interrupted and deflected medially, stocky body proportions, relatively rough skin on the back and sides, and often green coloration on the head and back (Platz and Mecham 1979). The species also has a distinctive call consisting of a relatively long snore of one to two seconds in duration (Davidson 1996, Platz and Mecham 1979). The Chiricahua leopard frog was designated a category 1 candidate (currently a "candidate") for Federal listing in 1994. Category 1 species and the current designation of candidate are those species for which the FWS has enough information on hand to support a proposed rule to list the species as threatened or endangered.

The Chiricahua leopard frog is an inhabitant of cienegas, pools, livestock tanks, lakes, reservoirs, streams, and rivers at elevations of 1,000-2,710 m (3,300 to 8,890 feet) in central and southeastern Arizona, west-central and southwestern New Mexico; and montane regions of Chihuahua, extreme northern Durango, and northern Sonora, Mexico (Sredl et al. 1997, Degenhardt et al. 1996, Platz and Mecham 1979). The range of the species is divided into two parts, including: 1) a southern group of populations that make up the majority of the species' range located in mountains and valleys south of the Gila River in southeastern Arizona south and east to extreme southwestern New Mexico and Mexico, and 2) northern montane populations in west central New Mexico and along the Mogollon Rim in central and eastern Arizona (Platz and Mecham 1979). Northern and southern populations exhibit morphological differences that may warrant description of two separate species (James Platz, Creighton University, Omaha, NE, pers. comm. 1996).

In the Basin, the Chiricahua leopard frog is only known to be extant in several tanks and springs on the west slope and bajada of the Dragoon Mountains east of Tombstone (Sredl et al. 1997). Historic records exist for the San Pedro River, numerous canyons on both the east and west slopes of the Huachuca Mountains, and the San Rafael Valley (Rosen et al. 1996, Clarkson and Rorabaugh 1989); however, a very similar, newly described species, the Ramsey Canyon leopard frog (*Rana subaquavocalis*) also occurs in the Huachuca Mountains, and some museum specimens from that range labeled as "*Rana chiricahuensis*" may actually be Ramsey Canyon leopard frogs. Recent surveys have failed to find Chiricahua leopard frogs at potential or historic habitats on the San Pedro River, that portion of the San Rafael Valley that is in the San Pedro River watershed, or the Huachuca and Whetstone mountains (Sredl et al. 1997, Rosen et al. 1996, Morrison et al. 1995, Wood 1991, Clarkson and Rorabaugh 1989). Declines noted in the Basin

are mirrored by similar declines throughout Arizona and New Mexico (Sredl et al. 1997, Jennings 1995). However, the status of the species in Mexico is unknown. Predation by nonnative fishes (such as sunfish and bass) and bullfrogs may be the most important cause of decline and extirpation of Chiricahua leopard frog populations (Rosen et al. 1996). However, habitat loss and degradation (Sredl et al. 1997, Ohmart 1995, Hendrickson and Minckley 1984), disease (Declining Amphibians Populations Task Force 1993), and environmental contamination (Rosen et al. 1996, Hale et al. 1995) are likely contributing factors. Loss of populations, particularly large, stable populations, has disrupted metapopulation dynamics, decreasing the likelihood that extirpated sites will be recolonized. Hale et al. (1995), note that declines of leopard frogs and another borderlands frog, the Tarahumara frog (*Rana tarahumarae*), are often exacerbated near copper smelters, such as the one at Cananea. Emissions from smelters may through slightly acidic precipitation or other causes lead to elevated cadmium to zinc ratios in aquatic sites, and subsequent cadmium toxicity in frogs (Hale et al. 1995).

ELEGANT TROGON

The elegant trogon is a member of a tropical family of birds that includes the resplendent quetzal and other colorful and graceful species. Elegant trogons are 28-30 cm (11-12 inches) in overall length, and males have a red abdomen, iridescent green on the head, throat, and back, and a coppery color on the upper tail surface. Females and juveniles are less colorful. Some consider this to be the most beautiful bird in the United States (Taylor 1994). Elegant trogons in Arizona are at the northern extreme of their range, which extends from southeastern Arizona south to the tropical deciduous forests of northwestern Costa Rica (Stiles and Skutch 1989). Evidence suggests that elegant trogons are expanding their range in Arizona, and may have been absent or very rare before the late 1800's (Taylor 1994). In Arizona, elegant trogons are found primarily in major canyon stream corridors lined with large sycamores that cut through pine-oak woodland. Trogons are cavity nesters, and often nest in sycamores (Taylor 1994).

In the Basin, elegant trogons are known primarily from the canyons of the Huachuca Mountains, particularly Garden, Huachuca, Ramsey, Scotia, and Sunnyside canyons. However, the species can be expected to occur in the Sierra de los Ajos, other canyons in the Huachuca Mountains, and it may occasionally visit or nest in other ranges in the Basin. Elegant trogons can be found in the Huachuca Mountains primarily from April to September, but some birds may winter in some years (Davis and Russell 1990). Apparently migrating birds are sometimes seen in late autumn on the San Pedro River (Taylor 1994).

The chance to glimpse an elegant trogon is part of what stimulates at least 50,000 birders to visit the borderlands of southeastern Arizona each year (Taylor 1994). The most accessible of the trogons, perhaps only a dozen individual birds in Arizona, support most of this onslaught of bird watchers (Taylor 1994). Among these most accessible elegant trogons are individuals that often spend the summer in Ramsey Canyon.

Beginning in 1977, another trogon species, the eared trogon or eared quetzal (*Eupilotus neoxenus*) began appearing in Arizona, first in South Fork of Cave Creek Canyon in the Chiricahua Mountains. This is a larger trogon than the elegant trogon; it is colored similarly, but lacks the white breast collar and coppery tail of its more common relative. In Mexico, this species

is a difficult to find bird of high elevation pine forests (Peterson and Chalif 1973). The species is now a regular visitor to Ramsey Canyon and has been reported from Miller Canyon and canyons at Fort Huachuca (Sheridan Stone, Fort Huachuca, pers. comm. 1996). Although it is a rare species in the Basin, it attracts many visitors. Sixteen percent of visitors to Ramsey Canyon come to see particular bird species. The eared trogon, white-eared hummingbird, and flame-colored tanager were mentioned most frequently by survey respondents as species they came to Ramsey Canyon to see (Crandall et al. 1992).

GILA CHUB

The Gila chub is a chunky, darkly-colored native fish, adults of which measure approximately 25-36 cm (10-14 inches) in length. Breeding males exhibit red or orange on the lower cheeks, lips, fin bases, and on ventro-lateral surfaces (Minckley 1973). Gila chub inhabit pools in springs, cienegas, and streams and is endemic to the Gila River basin, in which it has been recorded at more than 30 locations (Bestgen et al. 1985, Weedman et al. 1996). Of 32 natural populations, 22 are considered extant and 10 are believed to be extirpated (Weedman et al. 1996). Two of these 22 extant sites are recently-discovered populations in the Basin in Sonora (Varela-Romero et al. 1990). No other populations are known to be extant in the Basin. The species has also been reintroduced into three new sites, two of which are thought to support extant populations. In August 1997 the Gila chub was designated a candidate for Federal listing by FWS.

The Gila chub has been apparently extirpated from the mainstem of the San Pedro River. Its absence there is attributable at least in part to nonnative fish that prey on, compete with, and alter habitats of the Gila chub (Miller 1961, Meffe 1985, Rinne and Minckley 1970). This is a problem for virtually all native fish and many native amphibians in Arizona. Aquatic habitats of the fish have also been subject to a long history of human use in the form of water diversion, groundwater pumping, livestock grazing, woodcutting, and other activities that have degraded or eliminated habitat of native fishes (Hastings 1959, Hastings and Turner 1965, Hendrickson and Minckley 1984). Populations of Gila chub on the San Carlos Reservation have been found with skin lesions, probably due to contaminants (Weedman et al. 1996). Contaminants spills from leach ponds at the Cananea copper smelter into the San Pedro River may have contributed to the loss of this species from the river mainstem.

The Gila chub is significant as a surviving remnant of the San Pedro River's native fish fauna; a fauna that is now largely replaced by nonnative species. Because the San Pedro remains free-flowing and mostly unregulated, some believe it could be a key site for recovery of a suite of native fishes that includes the Gila chub, and other species currently extirpated from the mainstem (see Table 3). However, groundwater pumping in excess of recharge and potential subsequent loss of perennial flow (ASL 1994), and/or continued dominance of nonnative fish in the Basin may prevent realization of this recovery potential.

LESSER LONG-NOSED BAT

The lesser long-nosed bat is a small, leaf-nosed bat. It has a long muzzle and a long

tongue, and is capable of hover flight. These features are adaptations to feed on nectar from the flowers of columnar cactus, such as the saguaro and organ pipe cactus and from paniculate agaves, such as Palmer agave and Parry's agave (*Agave parryi*) (Hoffmeister 1986). Palmer agave exhibit many characteristics of chiropterophily, such as nocturnal pollen dehiscence and nectar production, light-colored and erect flowers, strong floral order, and high levels of pollen protein with relatively low levels of nectar sugar concentrations (Slauson 1996). Parry's agave demonstrates many (though not all) of these same morphological features (Gentry 1982). Slauson (1996) demonstrated that nectar feeding bats are the principle pollinators defining seed set in Palmer agave, though other pollinators may also be important. The lesser long-nosed bat was listed (originally, as *Leptonycteris sanborni*; Sanborn's long-nosed bat) as endangered on September 30, 1988 (53 FR 38456). No critical habitat has been designated for this species.

The lesser long-nosed bat is migratory and found throughout its historic range, from southern Arizona and extreme southwestern New Mexico, through western Mexico, and south to El Salvador. It has been recorded in southern Arizona from the Picacho Mountains (Pinal County) southwest to the Agua Dulce Mountains (Pima County), southeast to the Chiricahua Mountains (Cochise County), and south to the international boundary. Roosts in Arizona are occupied from late April to September (Cockrum and Petryszyn 1991); the bat is not known to be present during winter in Arizona (Hoffmeister 1986). In spring, adult females, most of which are pregnant, arrive in Arizona gathering into maternity colonies. These roosts are typically at low elevations near concentrations of flowering columnar cacti. After the young are weaned these colonies disband in July and August; some females and young move to higher elevations, primarily in the southeastern parts of Arizona near concentrations of blooming paniculate agaves. Adult males typically occupy separate roosts forming bachelor colonies. Males are known mostly from the Chiricahua Mountains but also occur with adult females and young of the year at maternity sites (Fleming 1995). Throughout the night between foraging bouts both sexes will rest in temporary night roosts (Hoffmeister 1986).

Loss of roost and foraging habitat, as well as direct taking of individual bats during animal control programs, particularly in Mexico, have contributed to the current endangered status of the species. Suitable day roosts and suitable concentrations of food plants are the two resources that are crucial for the lesser long-nosed bat (Fleming 1995). Caves and mines are used as day roosts. The factors that make roost sites useable have not yet been identified. Whatever the factors are that determine selection of roost locations, the species appears to be sensitive to human disturbance. Instances are known where a single brief visit to an occupied roost is sufficient to cause a high proportion of lesser long-nosed bats to temporarily abandon their day roost and move to another. Perhaps most disturbed bats return to their preferred roost in a few days. However, this sensitivity suggests that the presence of alternate roost sites may be critical when disturbance occurs. Interspecific interactions with other bat species may also influence lesser long-nosed bat roost requirements.

Activities that adversely affect the density and productivity of paniculate agaves and saguaros may adversely affect populations of lesser long-nosed bats. Clearing of vegetation for development; prescribed fire; vegetation manipulation, such as chaining, imprinting, or chemical control; and grazing all may adversely affect paniculate agaves and saguaros (Fleming 1995, Abouhalder 1992). Activities that directly or indirectly promote invasion or increased density of

nonnative grasses, particularly Lehmann lovegrass, species of (*Bromus*), and Mediterranean grass (*Schismus barbatus*) may result in increased fire frequency and intensity (Minnich 1994, Rogers and Steele 1980), and result in increased damage to agaves and saguaros.

Known major roost sites include 16 large roosts in Arizona and Mexico (Fleming 1995). According to surveys conducted in 1992 and 1993, the number of bats estimated to occupy these sites was greater than 200,000. Twelve major maternity roost sites are known from Arizona and Mexico. According to the same surveys, the maternity roosts are occupied by over 150,000 lesser long-nosed bats. The numbers above indicate that although a relatively large number of these bats are known to exist, the relative number of known large roosts is small. Disturbance of these roosts and the food plants associated with them could lead to the loss of the roosts. Limited numbers of maternity roosts may be the critical factor in the survival of this species.

Fleming (1995) identified two major lesser long-nosed bat roosts in or on the boundary of the Basin: the State of Texas Mine at Coronado National Memorial and Manilla Mine at Fort Huachuca. The Manilla Mine appears to be located just to the west of the boundary of the Basin. Within the US portion of the Basin, lesser long-nosed bats have also been found at Pyeatt Cave and Wren Bridge at Fort Huachuca; Ramsey Canyon, Miller Canyon, and San Pedro Riparian NCA (Sidner 1996, Cockrum and Petryszyn 1991). SIUE (1994) lists lesser long-nosed bat as occurring in the Mexican portion of the Basin, as well. Fort Huachuca and Coronado National Memorial actively manage recreation use at and near roost sites to protect the bats and the roost sites from human disturbance. Developing measures to avoid or minimize adverse effects to forage plants, particularly agaves, occurs on Federal lands during planning of projects that may affect these plants. Fort Huachuca has adopted an Agave Management Plan (Howell and Robinett 1996) to protect the most important concentrations of agaves at the Fort. The Fort limits training in these areas, including prohibiting off-road vehicle activity, pyrotechnics, and tank training, among other measures. Plans are underway to use prescribed fire to reintroduce a natural fire cycle into the Huachuca Mountains and other Madrean ranges. Howell (1996) developed recommendations for prescribed fire in agave habitat to ensure perpetuation of agave populations.

MONTANE RIPARIAN CANYONS: RAMSEY CANYON

Montane canyons in the Upper San Pedro River Basin, particularly in the Huachuca Mountains, are biotically very diverse. As a result of this biodiversity and the presence of many species representative of Sierra Madrean ecosystems to the south, montane canyons in the basin are recognized as some of the premier bird and other wildlife viewing areas in the country. Ramsey Canyon is one of the most visited canyons in the Basin, but others such as Garden, Huachuca, Scotia, Sunnyside, and Oversite canyons in the Huachuca Mountains, canyons of the Sierra de los Ajos, and French Joe Canyon in the Whetstone Mountains also have much to offer bird watchers, ecotourists, and other recreationists. Approximately 220 species of birds have been recorded in Ramsey Canyon, including many rare and interesting species, such as elegant and eared trogons, sulphur-bellied flycatcher, and Strickland's woodpecker. Ramsey Canyon is considered one of the best places in the country to view hummingbirds (Davis and Russell 1990). Coati, white-tailed deer, wild turkey, and other species are commonly encountered at close range

on the 300-acre Ramsey Canyon Preserve managed by The Nature Conservancy. Trails extend up the canyon to lands managed by the Coronado National Forest in upper Ramsey Canyon, and Wisconsin and Pat Scott canyons.

The recently-described Ramsey Canyon leopard frog is known only from Ramsey Canyon and two adjacent canyons. Conservation of this species is guided by an innovative multi-party conservation agreement that calls for protection of existing habitats and populations, and establishment of new populations. Successful implementation of the agreement has precluded the need for the US Fish and Wildlife Service to list this species as threatened or endangered. The Ramsey Canyon leopard frog was recently removed from the Federal candidate list.

Tourism generated by visits to Ramsey Canyon have contributed significantly to the local economy. Annual visitation to Ramsey Canyon in 1991-2 was 28,000. Average per day expenditure of non-resident visitors was $410.22, of which $55 was spent in Sierra Vista (Crandall et al. 1992). The economic impact on total industry output in the Sierra Vista area associated with nature-based visitors to Ramsey Canyon and the San Pedro Riparian NCA was roughly $2.7 million per year in 1991-2 (Crandall et al. 1992).

SAN PEDRO RIPARIAN NATIONAL CONSERVATION AREA

Like Ramsey Canyon, the San Pedro Riparian NCA supports a rich riparian community. The San Pedro River through the NCA is characterized by a relatively broad floodplain that meanders through the San Pedro River Valley. The riparian zone consists of cottonwood-willow and herbaceous associations near the river channel, to mesquite bosque on the higher terraces. Pond and marshland communities, saltcedar, four-wing saltbush, and grass associations also exist in the riparian zone of the river. The river is perennial from approximately Charleston to near Hereford.

The riparian corridor in the NCA is one of the most extensive, contiguous reaches of cottonwood-willow gallery forests in the Southwestern US. The San Pedro Riparian NCA supports a remarkably diverse mammalian fauna that includes many Mexican species at the northern edge of their range as well as species representative of grasslands and Chihuahuan desertscrub. Over 40 percent of all gray hawks that nest in the US occur in the San Pedro Riparian NCA. The green kingfisher, rarely observed in the US, also nests along the river (BLM 1989, Crandall et al. 1992). The area is also rich in cultural, archeological, and paleontological resources. The Lehner Mammoth kill site, the Presidio Santa Cruz Terrenate, and the Fairbank ghost town are popular visitor destinations. As discussed above for Ramsey Canyon, visitor use of the NCA contributes significantly to the economy of the Sierra Vista area. Birding and walking/hiking are the primary recreational pursuits in the San Pedro Riparian NCA (Crandall et al. 1992).

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Appendix E--A Bibliography of the Geology and Hydrology of the Upper San Pedro River Valley in Arizona and Sonora,

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Appendix F--Stakeholders

Governmental Agencies

Federal

Advisory Council on Historic Preservation
Bureau of Reclamation
Bureau of Indian Affairs
Coronado National Forest, US Forest Service
Coronado National Memorial, National Park Service
Council on Environmental Quality
International Boundary and Water Commission
National Park Service
Natural Resources Conservation Service
US Army Corps of Engineers
US Army, Fort Huachuca
US Border Patrol
US Department of Agriculture, Agricultural Research Service
US Department of Commerce
US Environmental Protection Agency
US Fish and Wildlife Service
US Geological Survey
Western Archaeological and Conservation Center, National Park Service

State

Arizona Agriculture and Horticulture Department
Arizona Department of Environmental Quality
Arizona Department of Health Services, Vector-Borne Zoonotic Disease Section
Arizona Department of Transportation
Arizona Department of Water Resources
Arizona Game and Fish Department
Arizona Office of Tourism
Arizona State Land Department
Arizona State Historic Preservation Officer
Arizona State Parks
Arizona State University
University of Arizona

Governmental Agencies (cont.)

Local

Benson City Council
Cochise County Board of Supervisors
Cochise County Planning & Zoning Department
Cochise County Public Works Department
Cochise Environmental Education Resource Center
Herford Natural Resources Conservation District
Huachuca, City of, Mayor
Reddington Natural Resources Conservation District, Benson, AZ
St. David Irrigation District
St. David Water Association
San Carlos Irrigation and Drainage District
San Carlos Tribal Council
San Pedro Natural Resources Conservation District
Sierra Vista City Government
Sierra Vista City Planning Office
Tombstone City Council
Upper San Pedro Technical Review Committee
Whitewater Draw Natural Resources Conservation District, Douglas, AZ

Indian Tribes

Ak-Chin (Maricopa) Papago
Gila River Pima
Salt River Pima
Tohono O'odham
San Carlos Apache

Organizations

American Rivers, Phoenix, AZ
Archaeological Conservancy
Arizona Association In and For Learning About the Environment
Arizona Cattlegrowers
Arizona 4-Wheel Drive Association
Arizona Wildlife Federation
Arizona Riparian Council
Arizona Trappers Association
Audubon Society - Huachuca Chapter
Audubon-Whittell Research Sanctuary, Elgin, AZ

Organizations (cont.)

Boy Scouts of America
Cochise College
Cochise Conservation Council
Cochise County Cattlegrowers
Coronado Resource Conservation and Development Area
Defenders of Wildlife
Friends of the San Pedro River
High Desert Garden Club
Huachuca Audubon Society
Huachuca Hiking Club
League of Women Voters
Republican Women's Club
San Pedro Advisory Committee
San Pedro Water Resources Association
Sierra Club
Sierra Vista Kiwanis International
Sierra Vista Lions Club
Sierra Vista Riding Club
Sierra Vista Rod & Gun Club
Sierra Vista Rotary
Society of Army Military Engineers
Southern Arizona Wildlife Callers
The Nature Conservancy
The Wildlife Society
The Wilderness Society
Tucson Rod and Gun Club
University of Arizona, Water Resources Research Center, Tucson, AZ
Westerner's International Officer's Club

Appendix G--Possible Components of a User-friendly Database

Resources and Management Issues. A database could contain the following information about resources and management issues:

- Identification and a brief description of the issue (e.g., water quality: under-treated sewage; acid mine drainage).
- Time frames. When did it begin? How long has the issue been recognized?
- A description of the impacts.
- An explanation of why it is an issue within DOI.
- Recommendations for issue resolution (e.g., plan of action).
- Sources of additional information and documentation on the issue (e.g., data bases).
- Suggestions or ideas as to how the issue can be portrayed graphically.
- Other significant information relevant to the issue.
- Name, telephone and telefax numbers of principle contact regarding the issue.

Stakeholders. Information concerning stakeholders will also be required and would be linked to the database described above. This is more complex because information is needed to facilitate and document communication between stakeholders and management entities. This will require separate data sets on those managing the issues and those contributing external input concerning the issues. The interests, responsibilities, concerns and abilities are very different for each. For the resource management agencies, the data set should include the regulatory authority or legal statute that triggers their involvement The data set could include all, or part, of the following:

- Date the communication occurred, with an assigned Control Number to allow for follow-up responses.
- Stakeholder Information.
  - Individual information including name, title, address, and telephone number.
  - Corporation information as to who the stakeholder was representing, their address, and telephone number.
- Concern
  - What is the category of their comments?
  - What is the subject of their comments?
  - Narrative.
- Receivership
  - Who took the communication and when?
  - What is the name and telephone number of the person receiving the information?
- Response
  - What action or response was taken to the communication?
  - Was it referred to someone else?
  - Who is assigned responsibility for an action or response to the stakeholder? Date,

name, title, DOI agency represented, address, and telephone number.

- What is the due date for the expected response?

◆ Documentation Information

- In order to tract correspondence and customer liaison, each stakeholder will need an individual file. Each stakeholder file will need to be unique (identifier; name), be easily located, and contain information on assignments, responses and reactions connected with that stakeholder.
- Documentation related to the stakeholder's interest, issue, or concern should be cross referenced or linked to the database on resources and management issues described above. In other words, all of the relevant information on the issue would be directly accessible from the stakeholders database, and vice versa.

Appendix H--Acronyms

Acronym	Description
ADWR	Arizona Department of Water Resources
AGFD	Arizona Game and Fish Department
APHIS	Animal, Plant, Health Inspection Service
ASARCO	American Smelting and Refining Company
BECC	Border Environment Cooperation Commission
BLM	Bureau of Land Management
BOR	US Bureau of Reclamation
CAP	Central Arizona Project
CEC	North American Commission for Environmental Cooperation
CIDESON	Sonora Center for Research and Development
CNA	National Water Commission
CONABIO	National Commission for the Understanding and Use of Biodiversity
DOA	Department of Agriculture
DOI	Department of the Interior
EOS	Earth Observing Systems
FCC	Department of the Interior United States-Mexico Border Field Coordinating Committee
FWS	US Fish and Wildlife Service
GEWEX	Global Energy and Water-cycle Experiment
GIS	Geographical Information System
GOALS	Global Ocean Atmosphere Land System
HACU	Hispanic Association of Colleges and Universities
IBWC	International Boundary and Water Commission
IMTA	Mexican Institute of Water Technology
INE	National Institute of Ecology
INP	National Fisheries Institute
LGEEyPA	General Law of Ecological Equilibrium and Environmental Protection
MOU	Memorandum of Understanding
MWD	Metropolitan Water District
NAAEC	North American Agreement on Environmental Cooperation
NADBank	North American Development Bank
NAFTA	North American Free Trade Agreement
NASA	National Aerospace Administration
NCA	National Conservation Area
NEPA	National Environmental Policy Act

Acronym	Description
NPS	National Park Service
NRCS	Natural Resources Conservation Service
PROFEPA	Federal Attorney General's Office of Environmental Protection
SALSA	Semi-arid Land Surface-Atmosphere
SANPES	System of Protected Natural Areas in the State of Sonora
SARH	Secretariat for Agriculture and Water Resources
SEDESOL	Secretariat of Social Development
SEDUE	Secretariat of Urban Development and Social Development
SEMARNAP	Secretariat for the Environment, Natural Resources and Fisheries
SEPESCA	Secretariat for Fishery Resources
SLD	Arizona State Land Department
TRC	Upper San Pedro Technical Review Committee
US	United States
USDA	United States Department of Agriculture
USEPA	US Environmental Protection Agency
USGS	United States Geological Survey
USFS	United States Forest Service
YDP	Yuma Desalinization Plant

Appendix I--Contributors

The following organizations and individuals contributed to the development of specific sections of this report. We wish to thank them for their time and contributions.

Preface

Bureau of Land Management
Beaumont C. McClure

Introduction

Bureau of Land Management
T.J. Kuka
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Background

Bureau of Land Management
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National Park Service
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Description of the Upper San Pedro River Basin

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